APRIL 1959

Journal

VOL. 51 • NO. 4

AMERICAN WATER WORKS ASSOCIATION

In this issue:

NUCLEAR ENGINEERING CONGRESS PAPERS
Moeller, Pecsok, Kramer, Klein, Branson, Hagee, Goldin, Karches, Straub

RADIOACTIVE CONTAMINATION AT CINCINNATI
Setter, Russell

COLORADO RIVER AQUEDUCT SUPPLIES
Diemer

FUTURE SUPPLIES AT LOS ANGELES
Grant

CALIFORNIA MOUNTAIN WATERS
Patric, West, Knoerr

DISTRIBUTION DESIGN CONSIDERATIONS
McPherson, Radziul

GROUND AND SURFACE WATER INTERRELATION
Rosenshein

JOB EVALUATION IN FLORIDA
Turvaville

ASSOCIATION ACTIVITIES IN 1958
Committee Reports

Checking Southern California's liquid assets at San Dimas Experimental Forest gaging station

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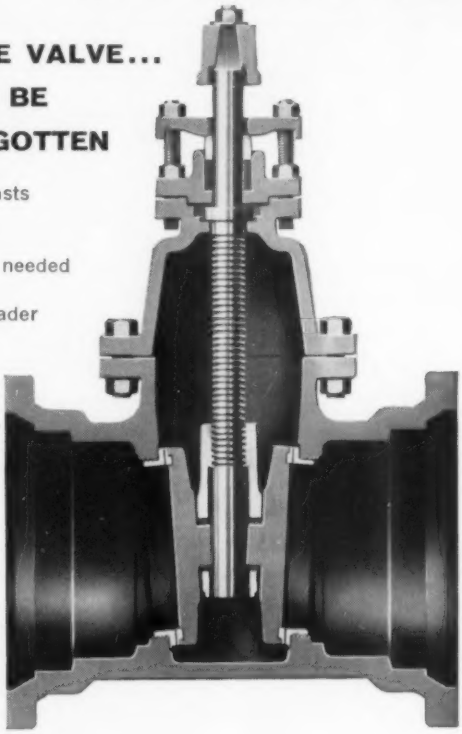

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April 1959

Vol. 51 • No. 4

Contents

Radiological Health Training for Supply and Pollution Control Personnel
DADE W. MOELLER, DONALD A. PECSOK & HARRY P. KRAMER 423

Concepts in Determining Potability of Water After Nuclear Attack
GERHARD KLEIN 431

Assembly and Operation of a Low-Level Counting Facility
BYRON M. BRANSON, G. R. HAGEE, A. S. GOLDIN, GERALD J. KARCHES & CONRAD P. STRAUB 438

Radioactive Contamination of the Environment in the Cincinnati Area
LLOYD R. SETTER & HELEN H. RUSSELL 449

Colorado River Aqueduct as a Source of Present and Future Supplies in Southern California ..... ROBERT B. DIEMER 463

Future Needs and Supplies at Los Angeles ..... BURTON S. GRANT 471

Increasing Water Yield in Southern California Mountains .. JAMES H. PATRIC 474

Water Losses in the Sierra Nevada ... ALLAN J. WEST & KENNETH R. KNOERR 481

Distribution Design Considerations ..... M. B. MCPHERSON & J. V. RADZIUL 489

Hydrologic Interrelations of Ground and Surface Waters at Lafayette
JOSEPH S. ROSENSHEIN 503

Job Evaluation of Water and Sewage Treatment Plants in Florida
LESTER J. TURVAVILLE 511

Reprints Available 520

Report of the Committee on Water Works Administration 521

Report of the Committee on Water Works Practice 527

Report on Publications 535

Report of the Committee on Water Utility Advancement 543

Report of the Audit of Association Funds 547

Section Membership Awards and Statistics 553

Departments

Officers and Directors ..... *2 P&R*
Coming Meetings ..... *6 P&R*
Percolation and Runoff ..... *35, 108 P&R*
Condensation ..... *62 P&R*
Correspondence ..... *104 P&R*
Employment Information ..... *112 P&R*
Service Lines ..... *114 P&R*
Index of Advertisers' Products ... *116 P&R*

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LIST OF ADVERTISERS

	P&R PAGE
Alabama Pipe Co.	—
Allied Chemical Corp., General Chemical Div.	61
Allied Chemical Corp., Plastics & Coal Chemicals Div.	—
Allis-Chalmers Mfg. Co.	—
Allis-Chalmers Mfg. Co., Hydraulic Div.	—
American Agricultural Chemical Co.	66
American Brass Co., The	—
American Cast Iron Pipe Co.	95
American Concrete Pressure Pipe Assn.	44, 45
American Cyanamid Co., Process Chemicals Dept.	71
American Pipe & Construction Co.	9
American Well Works	69
Anthracite Equipment Corp.	98
Aqua Survey & Instrument Co.	—
Armco Drainage & Metal Products, Inc.	67
Atlas Asbestos Co. Ltd.	—
Badger Meter Mfg. Co.	—
Bethlehem Steel Co.	119
B-I-F Industries, Inc.	5, 76, 77
Buffalo Meter Co.	25
Burgess-Manning Co., Penn Instruments Div.	—
Byron Jackson Pumps, Inc.	—
Calgon Co.	47
Calmet Meter Div., Worthington Corp.	109
Carborundum Co., The	27
Carus Chemical Co.	—
Cast Iron Pipe Research Assn., The	16, 17
Celanese Corp. of America	—
Centriline Corp.	—
Chain Belt Co.	—
Chapman Valve Mfg. Co.	—
Chemical Process Co.	—
Chicago Bridge & Iron Co.	115
Clow, James B., & Sons	7
Cochrane Corp.	—
Combination Pump Valve Co.	—
Darley, W. S., & Co.	98
Darling Valve & Mfg. Co.	113
De Laval Steam Turbine Co.	65
DeZurik Corp.	—
Dicalite Div.	87
Dorr-Oliver Inc.	Cover 3
Dresser Mfg. Div.	28
Eddy Valve Co.	7
Electro Rust-Proofing Corp.	121
Ellis & Ford Mfg. Co.	84
Emhart Mfg. Co., Maxim Div.	—
Fiese & Firstenberger	—
Filtration Equipment	—
Ford Meter Box Co., The	117
Foster Engineering Co.	—
Foxboro Co.	—
Gamon Meter Div., Worthington Corp.	39
General Chemical Div., Allied Chemical Corp.	61
General Filter Co.	81
Golden-Anderson Valve Specialty Co.	18
Graver Tank & Mfg. Co.	15
Graver Water Conditioning Co.	41
Greenberg's, M., Sons	—
Hagan Chemicals & Controls, Inc.	—
Hammond Iron Works	10
Hays Mfg. Co.	48
Hersey Mfg. Co.	63
Hungerford & Terry, Inc.	90
Industrial Chemicals, Inc.	—
Industrial Chemical Sales Div., West Virginia Pulp & Paper Co.	33
Inertol Co., Inc.	19
Infilco Inc.	37
International Salt Co., Inc.	123
Iowa Valve Co.	7
Johns-Manville Corp.	23
Jones Chemicals, Inc.	—
Keasbey & Mattison Co.	—
Kennedy Valve Mfg. Co., The	103
Klett Mfg. Co.	106
Koppers Co., Inc.	—
Kruger, Harold, Instruments	—
LaMotte Chemical Products Co.	84
Layne & Bowler, Inc.	75
Leadite Co., The	Cover 4
Leopold, F. B., Co.	93
Lock Joint Pipe Co.	3
Ludlow Valve Mfg. Co.	20, 21
M & H Valve & Fittings Co.	83
Millipore Filter Corp.	—
Monterey Sand Co.	108
Morgan Steel Products, Inc.	—
Mueller Co.	13
National Aluminate Corp.	—
National Water Main Cleaning Co.	89
Neptune Meter Co.	34
Northern Gravel Co.	29
Olin Mathieson Chemical Corp.	101
Orangeburg Mfg. Co.	53
Peerless Pump Div.	91
Permutit Co.	—
Philadelphia Quartz Co.	—
Photovolt Corp.	51
Pittsburgh-Des Moines Steel Co.	—
Pittsburgh Equitable Meter Div. (Rockwell Mfg. Co.)	124
Plastics & Coal Chemicals Div., Allied Chemical Corp.	—
Pollard, Jos. G., Co., Inc.	11
Portland Cement Assn.	99
Pratt, Henry, Co.	97
Precision Chemical Pump Corp.	—
Preload Co., Inc.	49
Reilly Tar & Chemical Corp.	43
Roberts Filter Mfg. Co.	—
Rockwell Mfg. Co.	124
Rockwell, W. S., Co.	107
Rohm & Haas Co.	12
Ronald Press Co.	—
Ross Valve Mfg. Co.	—
Servicised Products Corp.	79
Shawnee Mfg. Co.	—
Simplex Valve & Meter Co.	73
Smith, A. P., Mfg. Co., The	24
Southern Pipe & Casing Co.	31
Sparling Meter Co.	—
Steel Plate Fabricators Assn.	26, 105
Stuart Corp.	94
Taylor, W. A., & Co.	—
Taylor Iron Works	70
Tennessee Corp.	74
Trinity Valley Iron & Steel Co.	22
United Airlines	52
U.S. Pipe & Foundry Co.	—
Upson Co.	—
Vulcan Materials Co.	—
Wachs, E. H., Co.	14
Walker Process Equipment, Inc.	—
Wallace & Tiernan Inc.	32
Wheeler, C. H., Mfg. Co.	85
Wood, R. D., Co.	Cover 2
Woodward Iron Co.	111
Worthington Corp.	—

Directory of Professional Services—pp. *54-60 P&R*

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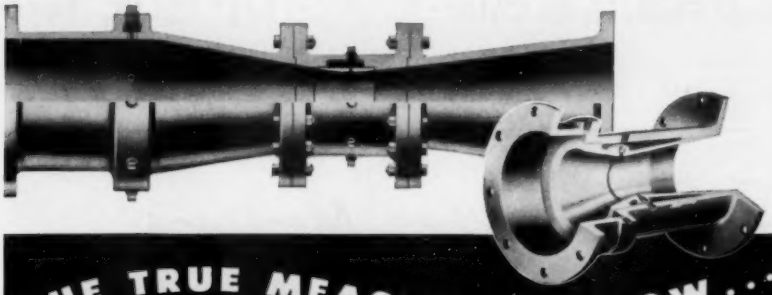

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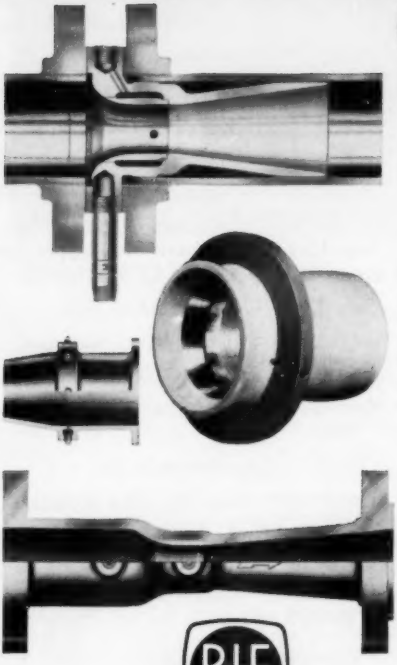

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Coming Meetings

AWWA SECTIONS

Spring 1959

Apr. 15–17—Nebraska Section, at Cornhusker Hotel, Lincoln. Secretary, Rupert C. Ott Jr., Repr., Neptune Meter Co., 2818—21st St., Columbus.

Apr. 16–18—Arizona Section, at Hi-Way House Hotel, Phoenix. Secretary, Stanford I. Roth, Supvr. of Water Collections, Div. of Water & Sewers, Phoenix.

Apr. 22–24—Kansas Section, at Besse Hotel, Pittsburg. Secretary, Harry W. Badley, Repr., Neptune Meter Co., 119 W. Cloud, Salina.

Apr. 23–25—Pacific Northwest Section, at Vancouver Hotel, Vancouver, B.C. Secretary, Fred D. Jones, W. 2108 Maxwell Ave., Spokane 11, Wash.

May 3–6—Canadian Section, at Queen Elizabeth Hotel, Montreal, Que. Secretary, A. E. Berry, Gen. Mgr. & Chief Engr., Ontario Water Resources Com., Parliament Bldgs., Toronto, Ont.

Jun. 3–5—Pennsylvania Section, at Salem House, Wernersville. Secretary, L. S. Morgan, Chief, Mine Drainage Sec., 413 First National Bank Bldg., Greensburg.

Fall 1959

Sep. 8–10—Rocky Mountain Sec.

Sep. 9–11—Wisconsin Sec., Milwaukee.

Sep. 14–16—Kentucky-Tennessee Sec., Lexington, Ky.

Sep. 16–18—New York Sec., Upper Saranac Lake.

Sep. 17–18—North Central Sec.

Sep. 23–25—Michigan Sec., Saginaw.

Sep. 27–29—Missouri Sec., Kansas City.

Oct. 7–9—Chesapeake Sec., Baltimore, Md.

Oct. 8–9—Intermountain Sec.

Oct. 14–16—Iowa Sec., Des Moines.

Oct. 18–21—Alabama-Mississippi Sec., New Orleans, La.

Oct. 18–21—Southwest Sec., New Orleans, La.

Oct. 22–24—New Jersey Sec., Atlantic City.

Oct. 28–29—West Virginia Sec., Parkersburg.

Oct. 28–30—Ohio Sec., Dayton.

Oct. 30—California Sec., Bakersfield.

(Continued on page 8)

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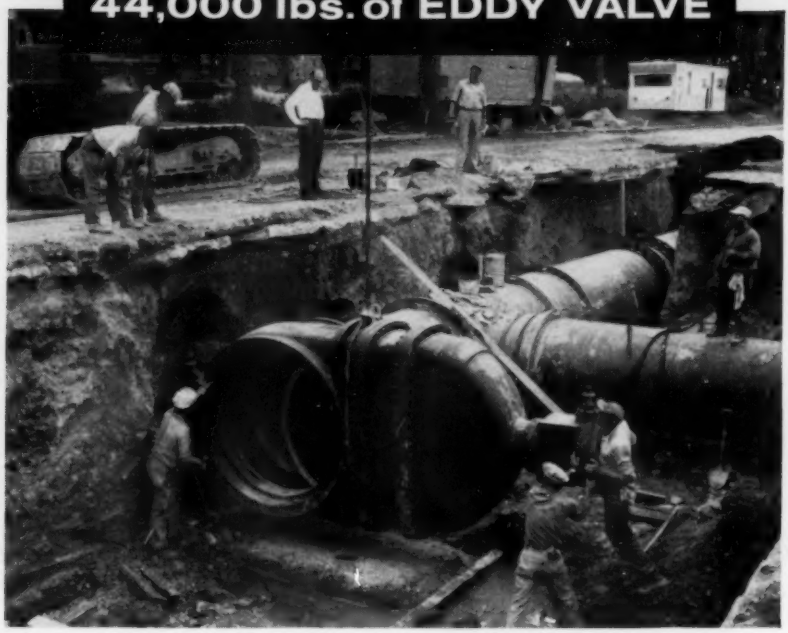

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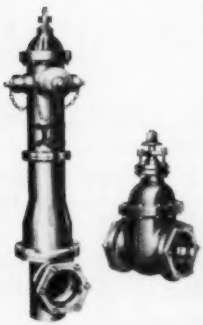

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Coming Meetings

(Continued from page 6)

Nov. 4–6—Virginia Sec., Roanoke.

Nov. 9–11—North Carolina Sec., Durham.

Nov. 15–19—Florida Sec., Tampa.

OTHER ORGANIZATIONS

Apr. 28–May 3—Consulting Engineers Council, Annual General Meeting, Biltmore Hotel, New York, N.Y. Write: Larry N. Spiller, Exec. Secy., 326 Reisch Bldg., Springfield, Ill.

May 4–15—Short course on "Sanitary Engineering Aspects of Nuclear Energy," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy., Cincinnati 26, Ohio (or to USPHS regional office).

May 5–7—Industrial Waste Conference, Purdue Memorial Union, Bldg., Purdue Univ., Lafayette, Ind.

May 18–20—Symposium on Instrumental Methods of Analysis, sponsored by Instrument Society of America, at Shamrock-Hilton Hotel, Houston, Tex.

May 24–27—National Telemetering Conference, sponsored by AIEE, ISA, and others, Cosmopolitan Hotel, Denver, Colo.

Jun. 2–4—Appalachian Underground Corrosion Short Course, School of Mines, West Virginia University, Morgantown, W.Va.

Jun. 8–9—Short course on "Industrial Water Conservation," School of Public Health, University of Michigan, Ann Arbor, Mich.

Jun. 17–20—NSPE Annual Convention & Engineering Progress Exposition, Hotel Commodore, New York, N.Y.

Jul. 20–Aug. 14—USPHS Summer Training Institute short courses, to be given at Western Massachusetts Public Health Center on campus of University of Massachusetts, Amherst Mass.: Jul. 20–31—Basic Radiological Health; Jul. 27–Aug. 7—Aquatic Biology for Engineers; Aug. 10–14—Bioassay & Pollution Ecology. Write: Sylvan C. Martin, Regional Engr., Region II, Rm. 1200, 42 Broadway, New York 4, N.Y.

Jul. 22–25—International Conference on Waste Disposal in Marine Environment, under multiple sponsorship, University of California, Berkeley, Calif.

Aug. 17–21—Short course on "Recent Developments in Water Bacteriology," R. A. Taft Sanitary Engineering Center, Cincinnati, Ohio. Write: Chief, Training Program, 4676 Columbia Pkwy., Cincinnati 26, Ohio (or to USPHS regional office).

Sep. 7–11—Ion-Exchange Conference, sponsored by Oak Ridge National Lab., at Gatlinburg, Tenn. (attendance limited). Write: Prof. William Rieman III, Vice-Chairman, Ion-Exchange Conference, R. G. Wright Lab., Rutgers State University, New Brunswick, N.J.

Sep. 13–18—American Chemical Society, Atlantic City, N.J.

Sep. 21–25—Instrument-Automation Conference & Exhibit, Instrument Society of America, International Amphitheater, Chicago, Ill. Write: H. S. Kindler, Director of Tech. & Educational Services, 313—6th Ave., Pittsburgh 22, Pa.

Sep. 28–Oct. 1—American Welding Society, Sheraton-Cadillac Hotel, Detroit, Mich.

Oct. 12–15—Federation of Sewage & Industrial Wastes Assns., Statler Hilton Hotel, Dallas, Tex.

Oct. 19–23—ASCE Annual Convention, Hotel Statler, Washington, D.C.

Oct. 20–22—ASA National Conference on Standards, Sheraton-Cadillac Hotel, Detroit, Mich.

Nov. 29–Dec. 4—ASME Annual Meeting, Chalfonte–Haddon Hall Hotel, Atlantic City, N.J.

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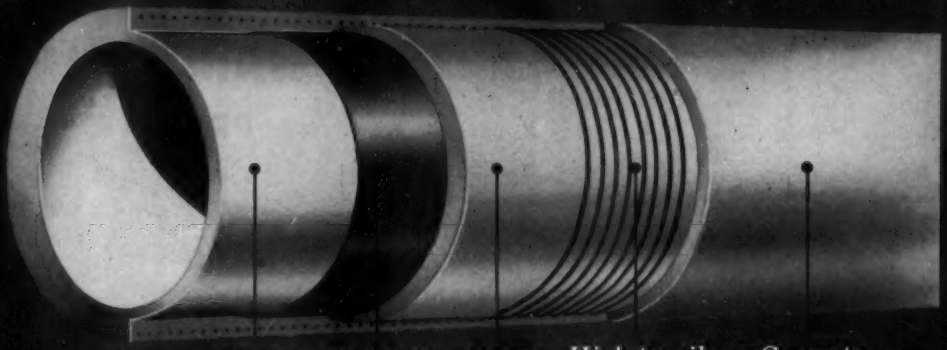

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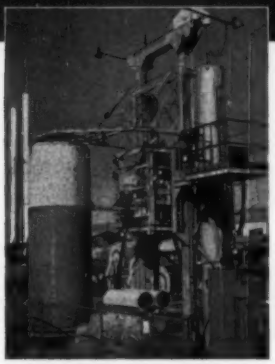

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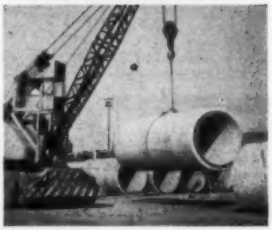

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HAMMOND Standpipes, Reservoirs, Elevated Tanks, Spheres, Filtration and Purification Units for Water Supply & Fire Protection Systems are built to all standard codes and specifications including those of the American Water Works Association, Associated Factory Mutual Fire Insurance Companies, the National Board of Fire Underwriters, the Factory Insurance Association.

Alexandria, La.
Radial Cone Elevated Water Tank

Capacity	1,000,000 Gal.
Tank Diameter	86 Feet
Range of Head	25 Feet
Tower Height	113 Feet

HAMMONDTANK

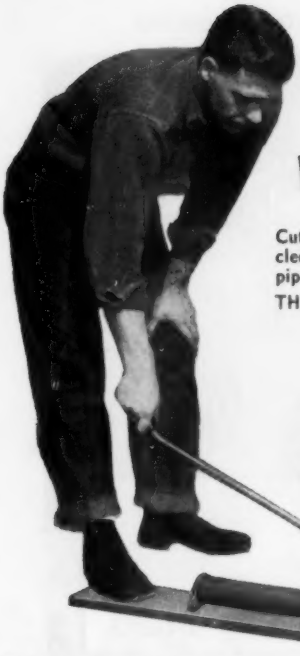
consulting engineer
H. L'Heureux & Assoc. Alexandria, La.

Catalog H_2O details and describes all **HAMMOND** Water Storage and Processing Vessels . . . Write for your copy.

HAMMOND IRON WORKS

WARREN, BRISTOL and PITTSBURGH, PA.
PROVO, UTAH • CASPER, WYO. • BIRMINGHAM, ALA.

Sales offices throughout the U.S.A.; licensees and sales offices in many foreign countries including Argentina, Belgium, Brazil, Canada, Colombia, Egypt, England, France, Haiti, Italy, Japan, Mexico, Netherlands, Peru and West Germany.



it's a snap!

with a

WHEELER HYDRAULIC PIPE CUTTER

NO VISE — NO TURNING — JUST SQUEEZE AND POP!

Cutter can be used in a ditch to cut pipe in a line with minimum clearance. All that's required is room to wrap the chain around the pipe.

THE HYDRAULIC MODEL CUTS —

- CLASS 150 AWWA WATER MAIN 4" thru 12"
- CLASS 250 AWWA WATER MAIN 4" thru 12"
- CEMENT LINED CAST IRON WATER MAIN 4" thru 12"
- STD. OR XH SOIL PIPE 6" thru 15"
- ASBESTOS CEMENT PRESSURE PIPE 6" thru 10"

— less than 2 minutes per cut —
a one man operation.

PIPE LINE EQUIPMENT

JOSEPH G. POLLARD CO., INC.

PIPE LINE EQUIPMENT

PIPE LINE EQUIPMENT

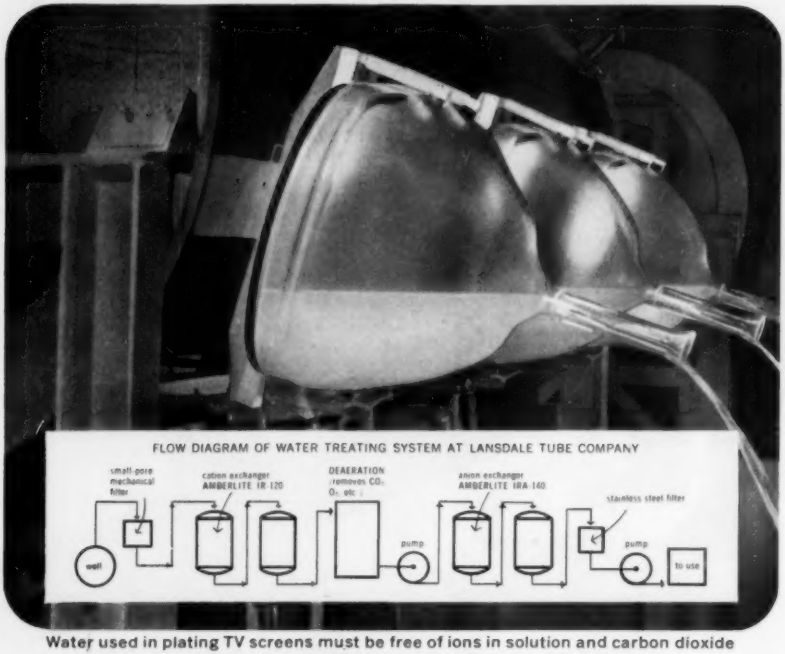
Place your next order with POLLARD

If it's from POLLARD . . . It's the Best in Pipe Line Equipment

NEW HYDE PARK • NEW YORK

Branch Offices: 964 Peoples Gas Building, Chicago, Illinois
333 Candler Building, Atlanta, Georgia

ION EXCHANGE RESINS pave the way for perfect TV pictures



Water used in plating TV screens must be free of ions in solution and carbon dioxide to prevent unwanted reactions and insure a smooth, blemish-free screen.

TV needs 100,000 gallons of AMBERLITE-treated water every day, at Philco's Lansdale Tube Co. Division

Plating the inside of picture tubes calls for water completely free of metallic impurities and carbon dioxide—for washing tubes and preparing phosphor solutions. At Philco's Lansdale Tube Co. Division, the water treating system teams AMBERLITE IR-120 cation exchange resin and AMBERLITE IRA-410 anion exchange resin to rid water of troublesome ions.

Water from the company's well contains 180 ppm hardness, 240 ppm dissolved solids, 150 ppm alkalinity. Deionized and filtered water shows over 600,000 ohm electrical resistance at 18°C. Further deionized water of 20,000,000 ohm resistivity at 18°C. for the manufacture of electronic components is obtained with small MONOBED units containing a mixture of AMBERLITE IR-120 and AMBERLITE IRA-400.

Your engineering company, qualified by experience in water conditioning, can tell you how AMBERLITE ion exchange resins can help you, or—write today for a copy of "If You Use Water".

AMBERLITE *and* MONOBED *are trademarks, Reg. U. S. Pat. Off. and in principal foreign countries.*

Chemicals for Industry

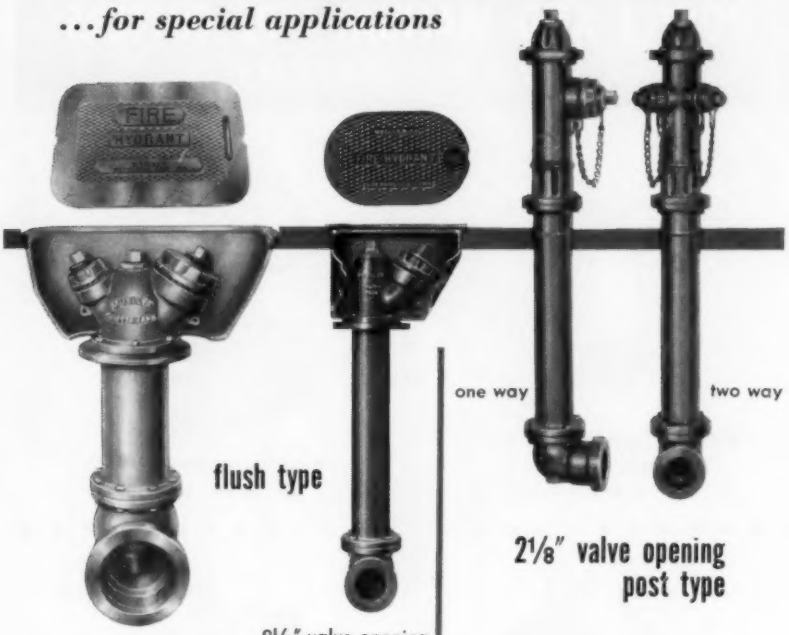
ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

MUELLER fire hydrants

...for special applications



flush type

AWWA 4¼" or 5¼" valve opening two way or three way

2⅛" valve opening one way

Uses:
Wherever post-type hydrant cannot be used, Airports, narrow streets, sidewalks, etc. Other restricted, heavy traffic areas

one way two way

2⅛" valve opening post type

Uses:
Fire protection for parks, country clubs, etc. Water supply for contractors and street sprinkling equipment.
Flushing dead ends

Full line of inlets available

Write today for complete details.

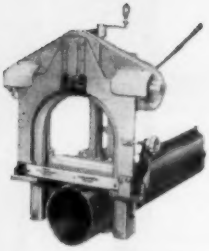
MUELLER CO. DECATUR, ILL.

Factories at: Decatur, Chattanooga, Los Angeles.
In Canada: Mueller, Limited, Sarnia, Ontario

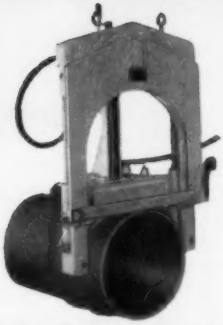
WACHS *Portable*

POWER AND MANUAL PIPE CUTTERS

2" TO 72" CAPACITY

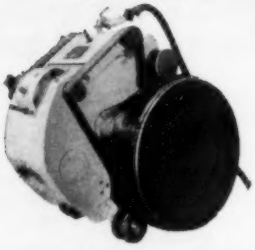


WACHS GUILLOTINE SAW
2" to 8" Capacity
Electric or Air Drive

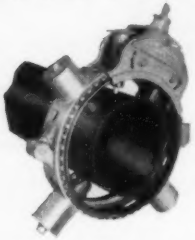


"BIG" GUILLOTINE SAW
10" to 16" Capacity

WACHS CHICAGO



WACHS NATIONAL SAW
"The milling machine on wheels"
Cuts 10" to 72" Pipe



WACHS STRICKLER RATCHET CUTTER
"Lathe Type Cuts"
5 sizes—2½" to 24" Capacity

Write for descriptive bulletins

THE E. H. WACHS COMPANY
Manufacturers of Engines, Valves and Machinery since 1883
1525 NORTH DAYTON STREET · CHICAGO 22, ILLINOIS

IT'S EASY TO RECOGNIZE QUALITY CONSTRUCTION

In some respects this 400,000 gallon elevated water tank is like a jig-saw puzzle. But fitted together by experienced Graver field-crews, all components of the 125′ high structure, precisely fabricated in Graver shops, match with the close tolerances that allow strong welds. Field work proceeds smoothly and on schedule, illustrating why Graver's undivided responsibility for design, fabrication and erection assures quality construction and maximum life.

GRAVER TANK & MFG. CO.
DIVISION—UNION TANK CAR COMPANY
Plants and Offices Across America

EAST CHICAGO, INDIANA

GRAVER®

BIG AD CAMPAIGN WARNS OF GROWING WATER PROBLEM!

Urges local support for better water systems

Cast Iron Pipe Research Association offers local plan-of-action booklet

Here's help for you and everyone else directly concerned with the supply, treatment and distribution of water—help that will acquaint the people in your town with the vital importance of this growing problem.

On the opposite page you see the second in a series of advertisements, this one appearing in April *Reader's Digest*. Placed by the Cast Iron Pipe Research Association, these striking advertisements point out to Mr. and Mrs. America how much we depend on a good water system and why we can no longer take it for granted.

Similar advertising will appear regularly in *U. S. News & World Report, Nation's Business, Better Homes & Gardens, American Home* and *Sunset* magazines to carry this public service message to millions of civic leaders and homeowners.

Free Local How-to-Help Booklet

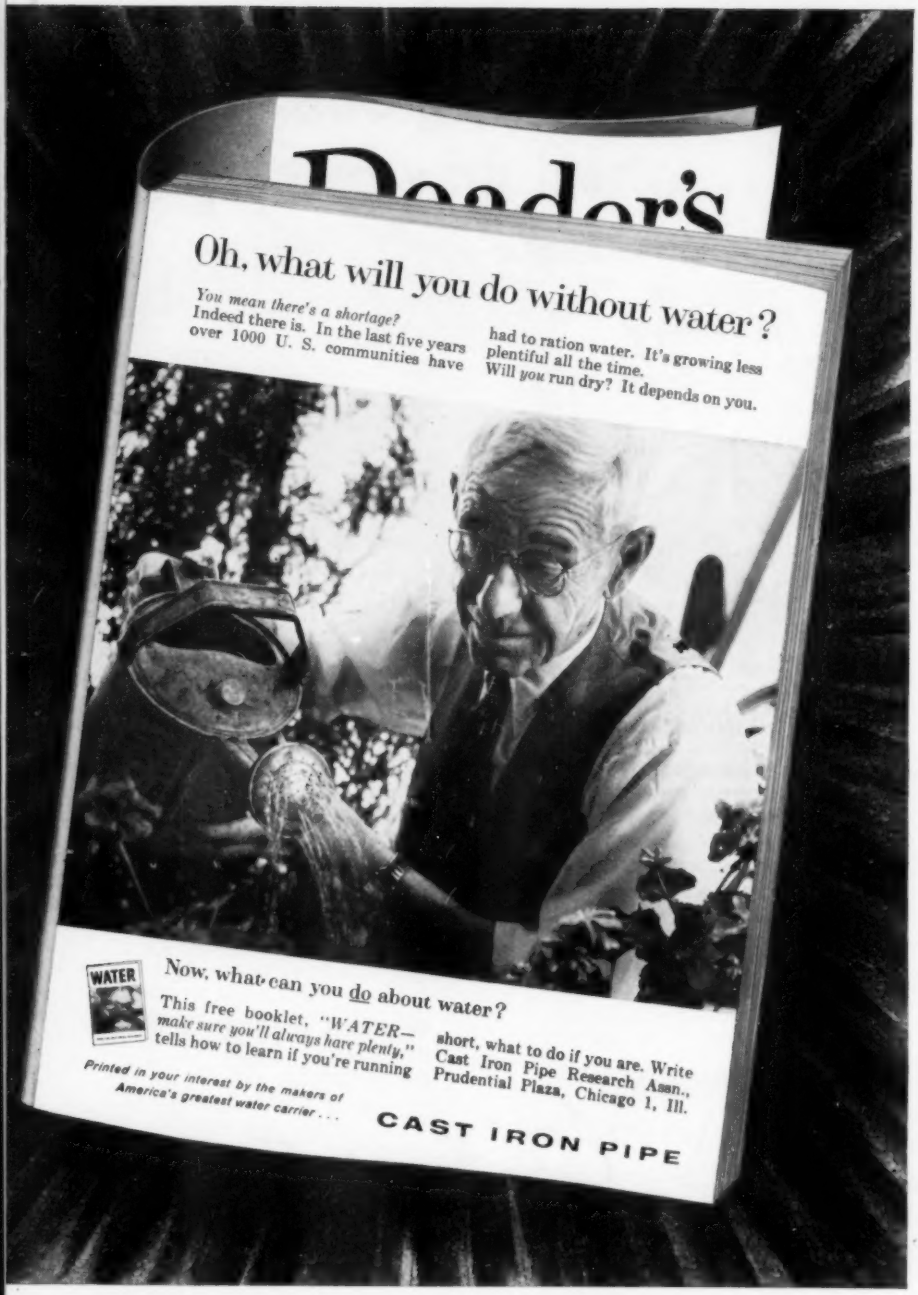
These ads offer a free booklet telling about the water problem. It shows how responsible citizens can acquaint themselves with the needs of their community. It also gives a step-by-step outline of action, telling how they can help their officials extend and improve the local water system through more adequate rate structures or financing.

Let us send you a free copy of this new booklet. Write to Thos. F. Wolfe, Managing Director, Cast Iron Pipe Research Association, 3440 Prudential Plaza, Chicago 1, Ill.

Three reasons why* cast iron pipe is *America's greatest water carrier:

1. More miles of underground cast iron water mains are now in use than of all other kinds of pipe combined.
2. More miles of cast iron water mains are now being purchased and laid than of any other kind of pipe.
3. Impartial surveys prove that today's consulting engineers and water utility officials prefer cast iron pipe for underground water distribution by an overwhelming majority.

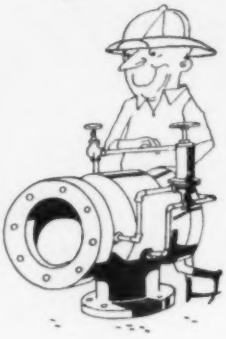
CAST IRON PIPE


Reader's
Oh, what will you do without water?
You mean there's a shortage?
Indeed there is. In the last five years over 1000 U. S. communities have had to ration water. It's growing less plentiful all the time.
Will you run dry? It depends on you.
WATER
Now, what can you do about water?
This free booklet, "WATER—make sure you'll always have plenty," tells how to learn if you're running short, what to do if you are. Write Cast Iron Pipe Research Assn., Prudential Plaza, Chicago 1, Ill.
Printed in your interest by the makers of America's greatest water carrier . . .
CAST IRON PIPE

CUSHION THAT SURGE

G-A *Cushioned* Surge Relief Valve

A sudden surge of power can be disastrous, but such excessive pressure in your water lines is quickly relieved by the Golden-Anderson Surge Relief or Surge Arrestor Valve. The surge relief valve opens immediately when line pressure reaches pilot setting—the surge arrestor valve anticipates surge and opens on subnormal pressure to prevent surge.



Sizes 2½" to 36" Pressures up to 400 psi.

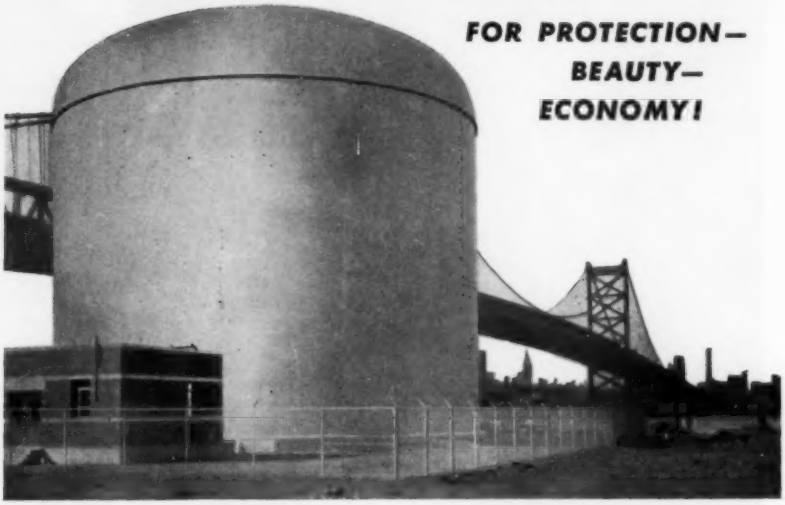
Write today for Technical Bulletins
Surge Relief—W2A
Surge Arrestor—W16

GOLDEN ANDERSON *Valve Specialty Company*

1221 RIDGE AVENUE, PITTSBURGH 33, PA.

Designers and Manufacturers of VALVES FOR AUTOMATION

Camden's new 5,000,000-gallon standpipe painted with Inertol®...



FOR PROTECTION— BEAUTY— ECONOMY!

• This 5-million-gallon standpipe can look forward to long years of maintenance-free economy, a trim, attractive appearance. Inside and out, it's protected with Inertol paints!

Exterior surfaces are guarded with Inertol's rugged, weather-resistant aluminum paint; interior surfaces, with Inertol's asphaltic tank paint . . . imparts neither taste nor odor to potable water.

Specified by Consulting Engineers Havens & Emerson, New York, these Inertol coatings meet the exacting requirements of water works service. Leading consulting engineers all over the country specify them again and again.

A prominent shipbuilding and manufacturing center, Camden, N. J., is one of many cities which benefit from Inertol coatings. *You,* too, can benefit from Inertol's 50 years' experience in protective-decorative coatings designed to withstand submersion, weather and harsh chemical and abrasive conditions of municipal and industrial service.

Send today, without obligation, for Inertol's "Engineers' Painting Guide" and "Tank Paints"—a handy portfolio of painting ideas. Just write us on your business letterhead, giving your title.

Ask about Rustarmor®, Inertol's new hygroscopically controlled rust-neutralizing paint —excellent for standpipe and water tank exteriors.

Inertol

A complete line of quality coatings for sewage, water and industrial wastes plants.

INERTOL CO., INC.

484 Frelinghuysen Avenue, Newark 12, N. J.
27G South Park, San Francisco 7, California

Visit our booth at AWWA and CSI conventions

TAPPING
TAPPING VALVES
TAPPING SLEEVES
TAPPING CROSSES
REPAIR SLEEVES

SAYS A CITY ENGINEER:

"L&R gate valves pass our 3-point test!"

Many engineers and waterworks superintendents ask themselves this question before specifying a particular gate valve:

"Does it operate easily, efficiently and dependably?"

Ludlow gate valves and Rensselaer gate valves meet all three of these basic requirements. They give you watertight closure through years of dependable, trouble-free performance. Simple in design and easy to operate, they exceed A.W.W.A. specifications.

FOR EASE AND DEPENDABILITY use Ludlow and Rensselaer tapping sleeves and valves for branchline connections to main lines under pressure.

WRITE FOR THE L&R GATE VALVE CATALOG, showing the most complete selection of outstanding design features available today. There are sizes from 2″ to 72″, plus custom designing for special applications.

LUDLOW & RENSSELAER
VALVES AND HYDRANTS

THE LUDLOW VALVE MANUFACTURING CO., INC., TROY, N. Y. – SINCE 1861

TRINITY VALLEY

For All Cast Iron Water Works Fittings

AWWA Standard Bell Spigot Watermain Fittings—2" through 36".

Ring Tite Fittings 3" through 16" Class 150. Class 100 through 12".

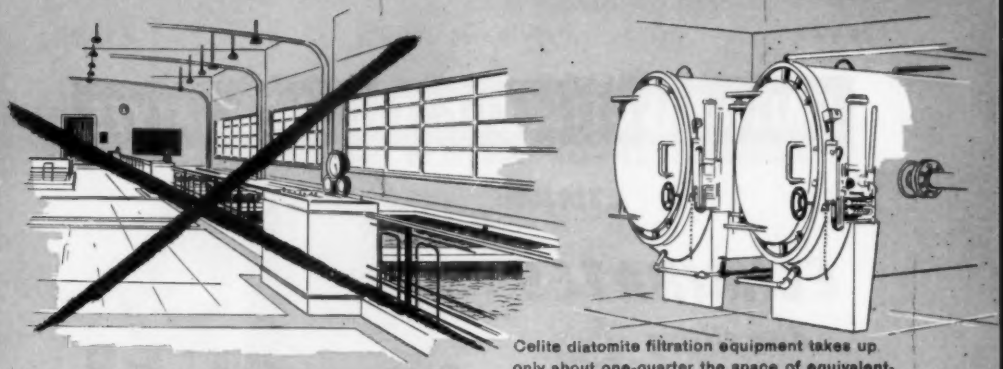
Short Body and Mechanical Joint Watermain Fittings—2" through 20".

Fluid-Tite Fittings 3" through 12" Class 150.

TRINITY VALLEY IRON AND STEEL COMPANY

Phone PE 8-1925 Fort Worth, Texas P. O. Box 664

1. REDUCE FILTER HOUSING SPACE 75%



Celite diatomite filtration equipment takes up only about one-quarter the space of equivalent-capacity sand filter systems.

2. USE LOWER-COST CONSTRUCTION

Smaller floor space needed for diatomite filtration permits lighter, lower-cost building methods and materials.

You save filtration construction dollars these 2 ways with Celite diatomite

One installation after another proves you need about 75% less filter housing space for equivalent capacity when you use diatomite filtration with Johns-Manville Celite*.

Also, diatomite's lighter, smaller equipment permits you to use lower cost building methods and materials. For example, a simple concrete slab with light framing and siding instead of a large reinforced concrete-and-brick building with built-in concrete filters#.

Diatomite filter equipment is so compact because it provides a much larger filter surface in proportion to size of equipment. In many cases, raw water can be filtered directly—pretreatment facilities can be eliminated. For Celite removes more suspended solids, including amoebae and algae, and turbidity is usually much lower.

Mined by Johns-Manville from the world's largest and purest commercial diatomite deposit, Celite is carefully processed for purity and uniformity. It is available in a wide range of grades for best practical balance of clarity and flow rate with any suitable filter. For further information, see your nearby Celite engineer. For free technical reprints and illustrated brochure, write to Johns-Manville, Box 14, N.Y. 16, N.Y. In Canada, Port Credit, Ont.

JM PRODUCTS

*Celite is Johns-Manville's registered trade mark for its diatomaceous silica products.

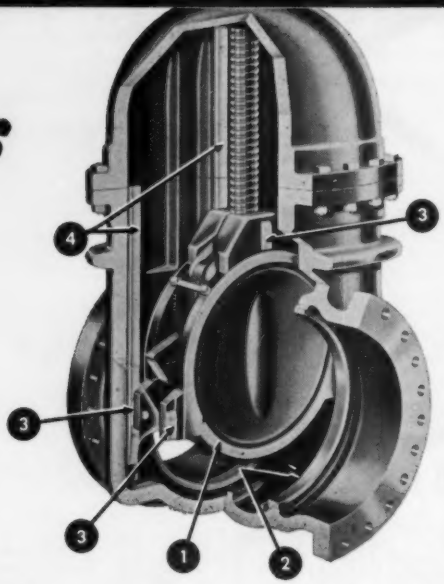
#*See Comparison Studies of Diatomite and Sand Filtration* by G. R. Bell, Journal American Water Works Association, September, 1956 or write for free reprint.

JOHNS-MANVILLE

SMITH THROTTLE CONSTRUCTION VALVES

ELIMINATES
disc tilting and chatter

REDUCES
wear of disc & seat ring faces



Smith Square Bottom Throttle Construction Valves have all of the time-proven design and construction refinements of standard Smith Gate and Tapping Valves and are recommended for severe service applications such as throttling in a partly open position, daily or frequent operation against high unbalanced pressure, high velocity or installation in a flat position in vertical piping.

The design features consisting of disc shoes and body tracks mechanically lift and hold the disc ring face (1) out of contact with the seat ring face (2) at all points of disc travel with the exception of the fully closed position.

Throttle construction valve discs are provided with three non-ferrous metal shoes (3), precision-machined and jig located. Valve bodies are provided with three non-ferrous metal machined tracks (4). The three disc shoes register with the three body tracks and each shoe is in contact with a track while the valve is unseated and in any partially open position. The bottom section of each track is bevelled to insure that the shoes will not bear on the tracks when the valve is fully closed.

This construction prevents damage to and uneven disc and seat face wear and assures long service life under severe operating conditions.

Single throttle construction is used when the flow is not subject to reversal. Double throttle construction when the flow is subject to reversal.

58

FIRE HYDRANTS · VALVES · SINCE 1896

THE A.P. SMITH MFG. CO.
EAST ORANGE, NEW JERSEY

AMERICAN METERS

HAVE WHAT THE WATER SUPERINTENDENT WANTS

American Frost Bottom Meter

QUALITY

that includes

- WORKMANSHIP
- DURABILITY
- ACCURACY

Everyone claims quality . . . finest quality . . . best quality — but like the pudding that is proven in the eating — so the proof of quality in a meter is in the running. This establishes its accuracy, and in continued running for long periods of time, its durability.

Judged on that basis, AMERICAN METERS are unsurpassed! For in operation, the fine workmanship, the excellence of manufacture of AMERICAN METERS are clearly demonstrated. AMERICAN METERS today are built to exceed the accuracy and life of meters built 35 years ago, that are still giving dependable accurate service. Yes truly, AMERICAN is a QUALITY WATER METER.

- *Quality Control at each manufacturing step insures the accuracy and reliability of American Meters.*

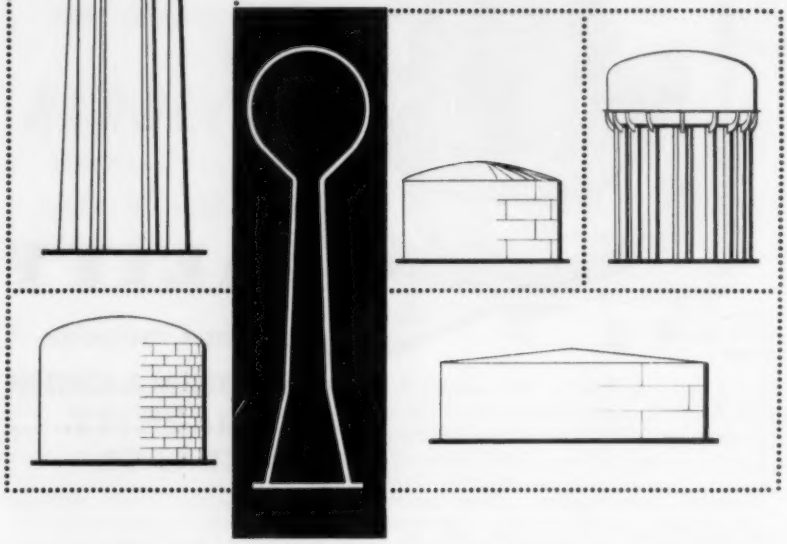
BUFFALO METER COMPANY
INCORPORATED

2914 Main Street
Buffalo 14, New York

STEEL TANKS

store water

BEST



Steel stands the test of time for enduring superiority in water storage. Your steel elevated tank, standpipe or reservoir is built to American Water Works Association specifications and can be erected any time of year without hazard. You get *known strength* in the structure, unaffected by the worst that weather or seasonal change can do over many years of useful life. You enjoy the simplest of maintenance—paint, instead of costly repair. Steel doesn't crack, spall or spoil—specify it for top dependability in all water storage applications.

STEEL PLATE FABRICATORS ASSOCIATION

105 West Madison Street
Chicago 2, Illinois

MR. K. F. KNOWLTON, Superintendent of Salem-Beverly, Mass. Water Filtration Plant, explains why:

"This filter bottom needs no maintenance, even after 5 years of operation"

"Our plant was built originally to handle 8 MGD, with conventional perforated cast iron laterals, and 18" of graded gravel supporting 30" of sand. Back in 1953 we installed these ALOXITE® aluminum oxide porous plates to get rid of the problem of shifting gravel layers. By 1955, the results had proved to be so good that we've been adding more porous bottoms every year.

"For one thing, we don't have to worry now about gravel beds being upset, or cleaning out mudballs. It's also very easy to move away the sand above ALOXITE plates so we can inspect the hold-down bolts or any part of the bottoms. It's easy to clean the filter, too. We use a minimum of washwater, and of course there's no more mixing of graded gravel and sand.

"Next, these porous plates have stood up well under rates of filtration far greater than the 8 MGD the plant was built to handle. One day this past summer, for example, we ran almost 15 MGD. During July and August, average daily consumption was over 10 MGD.

"Finally, these ALOXITE filters were the least expensive and most easily installed type of bottom for our existing structure. We were very careful about the installation — and this care has paid dividends in the excellent condition of the porous plates, the hold-down bolts, and the joints between the plates."

CARBORUNDUM

Registered Trade Mark

Dept. O-49, Refractories Division, Perth Amboy, N. J.

Always fair weather

. . . the Dresser way

Lenoir, North Carolina engineered this 10-mile, 20-inch water supply line to supply an additional 3 mgd. Gilbert Engineering and Pat O. Chester Construction Co. laid the 100 per cent Dresser-Coupled steel piping in 40 and 50 foot lengths.

When you specify Dresser® Couplings, you are much less vulnerable to delays caused by bad weather. If your crew can get in the trench, they can make the connections. All you need is a simple hand wrench to make permanently tight joints . . . no need for expensive welding equipment, no costly weather delays! And unlike rigid joints, the non-rigid Dresser Coupling protects the pipe from ground movement and stresses, remains bottle-tight even when absorbing shocks which can create costly maintenance problems in other piping.

GET THE MOST FOR YOUR TAX-PAYER'S DOLLAR: Be sure to specify Dresser-Coupled steel pipe on your next water line for the *least initial cost, lowest maintenance!*

Two man-minutes per bolt make bottle-tight joints for life!

Bradford, Pennsylvania

Chicago
Houston
New York
S. San Francisco
Toronto & Calgary

DRESSER MANUFACTURING DIVISION

ONE OF THE DRESSER INDUSTRIES

USE NORTHERN GRAVEL
for
RAPID SAND FILTER

FILTER SAND SPECIFICATIONS are carefully laid out. The Effective Sizes and Uniformity Coefficients used by Consulting Engineers and also recommended by the American Water Works Association are the result of long years of research and experience.

The Northern Gravel Company is equipped to give you prompt shipment whether it be one bag or many carloads, exact to specification. Filter sand can be furnished with any effective size between .35 MM and 1.20 MM.

CHEMICAL QUALITY of the filter sand is also important. It must be hard, not smooth and free of soluble particles. This requires perfect washing, and grading facilities. We have every modern device for washing, drying, screening and testing.

FILTER GRAVEL supporting the Filter Sand Bed must be, in turn, properly graded to sizes calculated to support the Filter Sand, and be relatively hard, round and resistant to solution.

The new Northeast Station in the City of Detroit, recently completed, is one of the major projects included in the water department's expansion program. The Northern Gravel Company furnished 120 carloads of filtering materials for the 48 rapid sand filters incorporated in this plant.

Northern Gravel has no equal in facilities and our reserves of both sand and gravel are inexhaustible. Northern Gravel Company has been in business over 40 years. We guarantee uniformity of products and our records enable us to duplicate your requirements on short notice. Our location is central and we have commodity rates in every direction.

NORTHERN GRAVEL COMPANY

Muscatine, Iowa

P.O. Box 307 **Phone: Amherst 3-2711**

New AWWA

35-mm

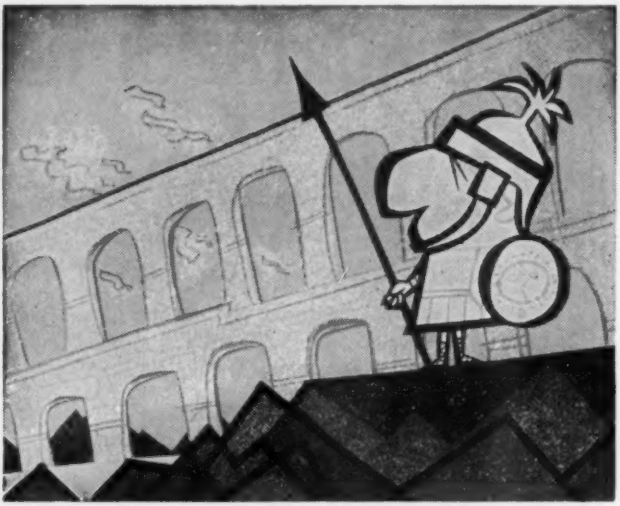
Slide Film

with

Sound and

Color

$35 a copy



THE STORY OF WATER SUPPLY

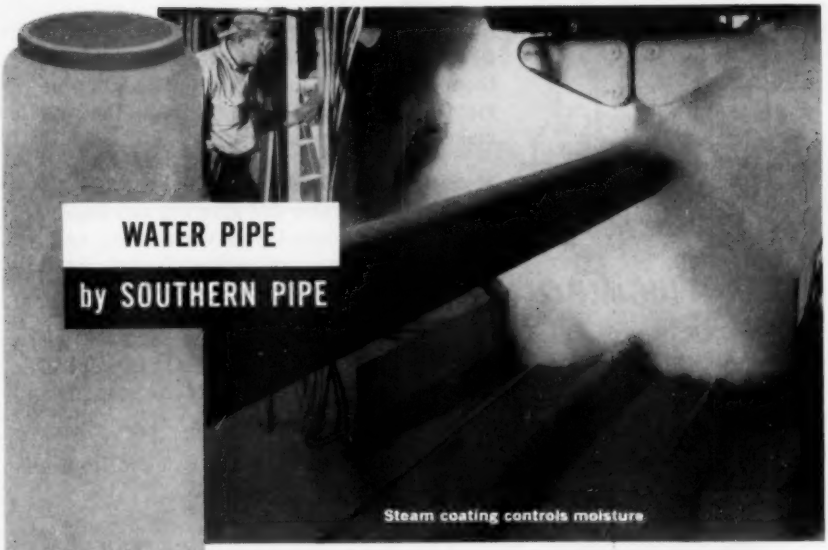
Based on AWWA's million-copy bestselling picture booklet of the same name, the film version uses lively color cartoon slides and synchronized sound to tell "The Story of Water Supply" to schools, civic clubs, and other groups of your neighbors and customers. Attractive to both youngsters and adults, and easily understood by all, the effectiveness of this 15-minute presentation is being proved throughout the country.

Whether you use the film as an introduction to a talk on local water problems or lend it to your schools (a teaching guide comes with it), you're bound to find that its value as a public relations tool is worth far more than the modest $35 cost.

Order Now From

AMERICAN WATER WORKS ASSOCIATION

2 Park Avenue **New York 16, N.Y.**

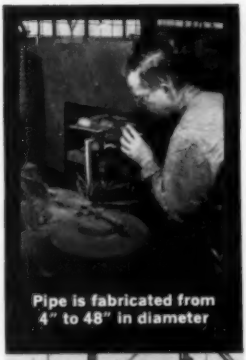


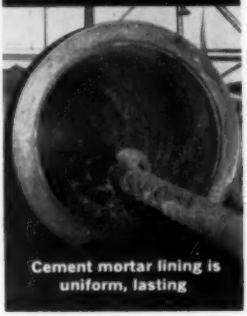
STEAM FOR STRENGTH

Southern Pipe's exclusive steam coating process means greater early strength, higher early set. Water pipe that sets stronger, quicker, is less liable to damage. There is no excess moisture; coating is less permeable. Customers get better corrosion protection.

Cement Mortar Lined and Coated Steel Pipe is one of many types of quality water pipe completely fabricated and processed in Southern Pipe's own plant.

Find out more about Water Pipe by Southern Pipe. Write for illustrated brochure.


Pipe is fabricated from 4" to 48" in diameter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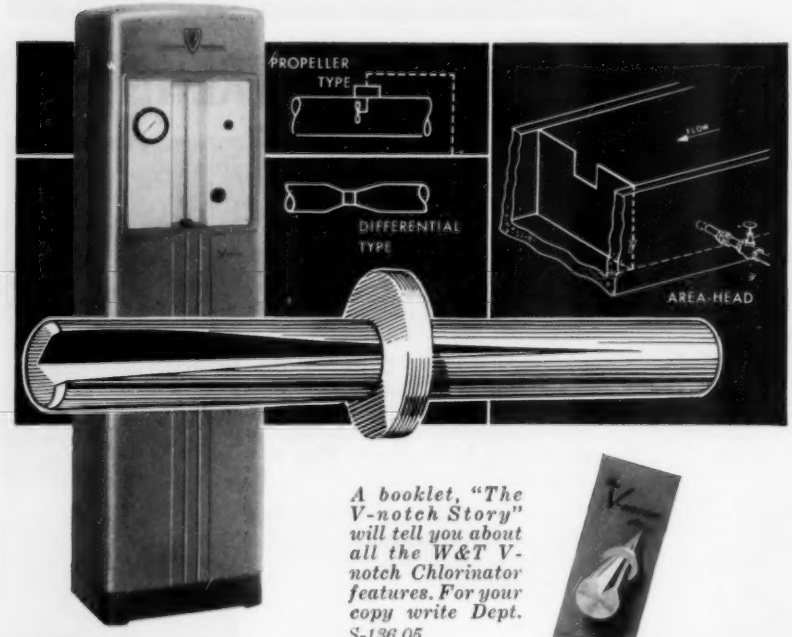

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Radiological Health Training for Supply and Pollution Control Personnel

Dade W. Moeller, Donald A. Pecsok, and Harry P. Kramer

A paper presented on Apr. 6, 1959, under the sponsorship of AWWA, at the Engineers Joint Council's Nuclear Eng. and Science Congress, Cleveland, Ohio, by Dade W. Moeller, Chief, and Donald A. Pecsok, Asst. Chief, Radiological Health Training Div. of Radiological Health, and Harry P. Kramer, Chief, Training Program, all of the Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

AT the Robert A. Taft Sanitary Engineering Center, Cincinnati, USPHS, conducts a comprehensive program of specialized, technical, training courses in the field of radiological health.

The rapidly growing exploitation of nuclear energy resources presents serious problems of environmental radiation. These problems are amenable to control, but only if those charged with protection of the public health as it relates to the environment have the necessary training and experience in the public health aspects of nuclear science and technology. A first step in such training is the creation of an awareness among those for whom the training is designed of the complex task of assessing man's total radiation exposure, which today comes from many sources in a variety of ways. Of the environmental ways water is of major importance because it carries a large percentage of the wastes discharged from nuclear installations.

The people who are charged with responsibility for water supply and pollution control, operating in their traditional role of assessing water quality, are faced with the challenge of a new field in which control must be exercised. In order to do this they must acquaint themselves with the special vocabulary, instrumentation, and techniques of nuclear science and technology. To meet this challenge two types of curricula are required and, fortunately, are available: long-term academic training, which too often is not practicable for control personnel, and short-term specialized technical training.

USPHS, through its Division of Radiological Health and the National Institutes of Health, and AEC provide support for formal academic training. Short-term training is available from a number of universities, from the Institute of Nuclear Studies, Oak Ridge, Tenn., and from USPHS through the training program of the Robert A. Taft Sanitary Engineering Center.

Courses

Since 1950, USPHS at the Taft Center has sponsored a series of specialized, technical training courses in radiological health practices. Personnel attending these courses have been drawn from federal, state, and local regulatory agencies, from industry, and from university staffs. These courses have grown in content and scope in keeping with the rapidly developing field of nuclear energy. At present (December 1958), nine courses are offered, two of them specifically directed toward personnel responsible for water quality. These two courses are titled: Basic Radiological Health and Radioactive Pollutants in Water. A third course, Determination of Radionuclides, is planned for the fall of 1959. In addition to these, significant portions of two other courses, Sanitary Engineering Aspects of Nuclear Energy and Environmental Health Aspects of Nuclear Reactor Operations, are devoted to problems related to the fate of radioactive liquid pollutants in the environment.

The overall purpose of the training program is to reduce the time interval between the acquisition of new knowledge and its application. The courses are professional in nature, the bachelor degree being a prerequisite. Classrooms and laboratories at the Taft Center are utilized in the presentation of the courses. No tuition fee is charged and the agency sponsoring the candidate provides his or her salary and traveling expenses. To insure attention to individual needs the courses are restricted to approximately 25 trainees.

Basic Radiological Health

The 2-week Basic Radiological Health course emphasizes the basic nuclear physics and chemistry necessary for a technical understanding of radiological public health problems. Intensive coverage of the major sources of radiation exposure, the mode of radiation injury, and the basic units and terminology associated with this field are provided. Existing standards for radiation protection are also included. The use, operation, and calibration of laboratory and field survey instruments necessary for the evaluation of specific problems are discussed in detail. Almost 50 per cent of the scheduled instruction time is devoted to laboratory and problem sessions. A typical curriculum for this course is listed below:

1st Day

9:00– 9:45	Registration and Welcome
9:45–10:15	Preview of Course
10:30–11:15	Sources of Radiation Exposure
11:15–12:30	Atomic Structure (Lecture and Film)
1:30– 3:00	Radioactivity (Lecture and Film)
3:00– 3:30	Chart of the Nuclides and Seaborg Tables
3:30– 4:30	Tour of the SEC

2nd Day

8:30–10:00	Interaction of Radiation with Matter (Lecture and Film)
10:00–10:15	Demonstration: Cloud Chamber
10:30–11:30	Personnel Instruments
11:30–12:30	Demonstration: Film Badges and Pocket Chambers
1:30– 2:30	Survey Instruments
2:30– 4:15	Laboratory: Calibration of Survey Meters

3rd Day

8:30– 9:30	Examination No. 1
9:45–10:30	Units of Radioactivity and the Decay Law
10:30–11:15	Decay Problems
11:15–12:00	Laboratory Instruments for Alpha and Beta Counting
12:00–12:30	Demonstration: Laboratory Instruments
1:30– 4:15	Laboratory: Introduction to Counting Techniques

4th Day

8:30– 9:15	Examination No. 2
9:30–10:30	Counting Techniques
10:30–11:15	Counting Statistics
11:20–12:30	Assay of Radionuclides: Beta Emitters
1:30– 3:30	Laboratory: Determination of Half-Life
3:30– 4:15	Review of Examination No. 2

5th Day

8:30– 9:00	Examination No. 3
9:00– 9:45	Units of Radiation Exposure
10:00–11:00	Biological Effects of Ionizing Radiation
11:00–11:50	Maximum Permissible Concentrations
11:50–12:30	Correlation of Units of Activity and Exposure
1:30– 3:30	Laboratory: Counting Efficiency
3:30– 4:15	Review of Examination No. 3

6th Day

8:30– 9:20	Basic Principles of Radiation Protection
9:35–10:20	Survey Techniques
10:25–11:35	X-rays (Lecture and Film)
11:40–12:30	Particle Accelerators
1:30– 3:30	Laboratory: X-rays
3:30– 4:15	Examination No. 4

7th Day

8:30– 9:20	Charged Particles and Photons
9:35–10:45	Neutrons (Lecture and Demonstration)
10:45–12:30	Fission and Fusion (Lecture and Film)
1:30– 3:30	Laboratory: Shielding
3:30– 4:15	Review of Examination No. 4

8th Day

8:30– 9:15	Gamma Scintillation Spectrometer
9:15–10:00	Assay of Radionuclides: Gamma Emitters
10:15–11:30	Natural and Artificial Background (Lecture and Film)
11:30–12:30	Nuclear Detonations—Origin of Fallout
1:30– 3:30	Laboratory: Assay of Radionuclides: Beta Emitters
3:30– 4:15	Examination No. 5

9th Day

8:30– 8:45	Review of Examination No. 5
8:45–10:00	Basic Principles of Nuclear Reactors (Lecture and Film)
10:15–11:00	Control of Radioactive Materials
11:00–11:35	Medical Applications of Radiation
11:35–12:10	Industrial Applications of Radiation
12:10–12:30	Sources of Information in Radiological Health
1:30– 3:30	Laboratory: Assay of Radionuclides: Gamma Emitters
3:30– 4:15	Review for Final Examination

10th Day

8:30– 9:45	Final Examination
10:00–10:45	Disposition of Reactor Wastes
10:45–11:30	Radiation Sterilization of Foods
11:45–12:30	Uranium Ore Refinery Wastes
1:30– 2:00	Review of Examination
2:00– 2:30	Critique and Graduation
2:30– 4:30	Consultation With SEC Staff as Desired

This curriculum has changed markedly during the last 8 years. During this period, the course has been presented at the Taft Center 31 times with a total of 601 persons attending. The professional affiliation of some of these trainees is shown in Table 1, which covers the three courses presented in 1958.

Completion of the Basic Radiological Health course is recommended as a prerequisite to the other two courses.

Radioactive Pollutants in Water

The course entitled Radioactive Pollutants in Water provides intensive training on radioactive contamination of the aquatic environment. Particular emphasis is given to water monitoring techniques, including sampling, analysis, and the interpretation of data. More than 50 per cent of the time of the course is devoted to laboratory practice utilizing, on an individual basis, commercially available monitoring instrumentation. This course is currently designed for presentation within a 5-day period. A typical curriculum is given below:

TABLE 1

Employing Organizations of Personnel Trained in 1958

Employing Organization	Course	
	Basic Radiological Health	Radioactive Pollutants in Water
State and local health departments	16	17
USPHS	15	6
US Department of Defense	24	6
Other government agencies	6	7
University faculty	1	2
Industry	21	3
Foreign countries	5	1
Total	88	42

1st Day

8:30– 9:15	Registration and Welcome
9:15–10:00	Radioactivity in Water—The Problem
10:15–11:50	Radiation and Radioactivity (Lecture and Film)
11:50–12:30	Units of Radioactive Decay and the Decay Law
1:30– 3:30	Stream Sampling Techniques (Lecture and Demonstration)
3:15– 4:00	Tour of Radiological Laboratories at SEC
4:00– 4:30	Laboratory: Preparation of Water Sample A

2nd Day

8:15– 9:15	Radiation Exposure in the United States
9:30–10:30	Waste Disposal Criteria
10:30–11:00	Demonstration: Uptake of Radionuclides by Biota
11:00–11:30	Review and Discussion
11:30–12:30	Laboratory Instruments for Alpha and Beta Counting
1:15– 2:00	Determination of Gross Radioactivity
2:00– 2:15	Demonstration: Preparation of Alpha and Beta Standards
2:15– 4:30	Laboratory: Counting of Beta Standards and Sample A for Beta Activity

3rd Day

8:15– 9:15	Counting Statistics: Evaluation of Sample A; Counting Data
9:30–10:00	Waste Disposition from Radionuclide Users
10:00–11:00	Nuclear Reactor Operations—Effects on Water Resources
11:00–11:45	Weapons Test Fallout

11:45–12:30	Civil Defense Aspects of Water Contamination
1:15– 2:15	Laboratory: Counting of Alpha Standard and Sample A for Alpha Activity
2:15– 3:15	Review and Discussion
3:30– 4:30	Laboratory: Determination of Radiostrontium in Water

4th Day

8:15–10:30	Radiochemical Analytical Procedures
10:30–11:30	Demonstration: Use of Absorbers for Assay of Beta Emitters
11:30–12:30	Demonstration: Use of Gamma Spectrometer for Assay of Sample A
1:15– 4:00	Laboratory: Determination of Radiostrontium in Water (Concluded)
4:00– 4:30	Laboratory: Preparation of Water Sample B

5th Day

8:15–10:15	Discussion: Establishment of a Water Surveillance Program
10:30–11:30	Radiological Research Needs
11:30–12:30	Laboratory: Counting and Evaluation of Sample B
1:30– 2:00	Review of Sample B Assay Results
2:00– 2:45	Hydraulic Studies Using Radiotracers
3:00– 3:30	Applications of Radiation in Water Analysis
3:30– 4:00	Course Critique and Closing

During the last 5 years, 9 sessions of this course have been presented at the SEC with a total of 183 persons attending.

Determination of Radionuclides

When radioactive materials in water supplies approach the order of maximum permissible concentrations gross measurements are no longer adequate for evaluation of the health problem. Analyses for specific nuclides require special techniques of instrumentation and chemistry. A course on the determination of radionuclides is, therefore, being established in the training program at the Taft Center. This course is scheduled for initial presentation in the fall of 1959 and will be of 2 weeks duration.

Emphasis will be placed in this course on those radionuclides of primary health significance which are commonly released or dispersed into the aquatic environment. Techniques for evaluation will be principally based on radiochemical separation and alpha and gamma spectroscopy.

Staff and Facilities

A professional staff consisting of a sanitary engineer, a radiochemist, a radiobiologist, a health physicist, a nuclear engineer, and an electronics specialist organizes and conducts all radiological health courses presented. This staff is supplemented by:

1. Personnel from radiological health and other research programs at the Taft Center.
2. Personnel from other USPHS installations
3. Consultants from other government agencies such as AEC and its national laboratories, USGS, and the National Bureau of Standards
4. Consultants from state health departments, universities, and private industry.

More than $75,000 worth of specialized radiological instrumentation, including internal proportional and Geiger-Mueller counters and gamma spectrometers (Fig. 1), is used in the courses. Figures 2 and 3 show other facilities and equipment used in the courses.

Due to the intensive nature of the radiological health training program a specialized manual has been developed

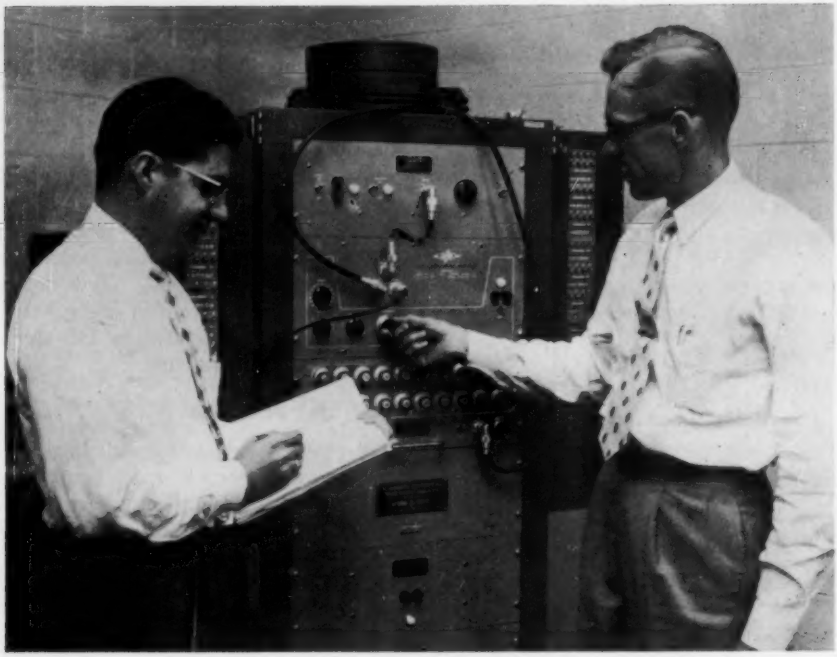


Fig. 1. Pulse Height Analyzer

This instrument, used with a gamma scintillation spectrometer, is shown here being operated by two engineer trainees.

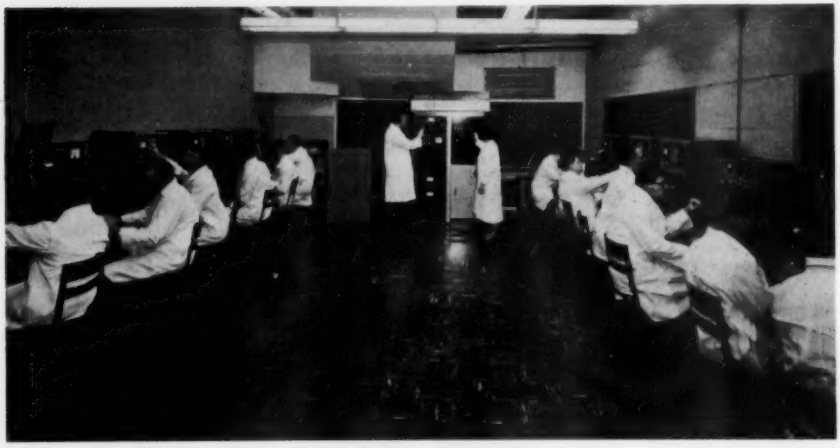


Fig. 2. Counting Room

Internal proportional counters are being used in a counting room of the SEC.

for each course. The manuals are produced at the Taft Center and are flexible in content, which enables the staff to continually incorporate new developments. Where practicable reference copies of these manuals are made available to the libraries of schools of public health and sanitary engineering and to state agencies.

come to Cincinnati, Ohio. For this reason certain courses are offered from time to time in the field—consistent with budgetary limitations. During the summer of 1958 a training institute was conducted in the laboratories and classrooms of the University of California, Berkeley, for personnel in the western states. A 2-week course in

Fig. 3. Radiochemistry Laboratory

Samples are prepared for counting in this laboratory at the SEC.

Special Activities

Research activities at the Taft Center offer unusual opportunities to the visiting trainee to acquire answers to related professional problems. This research, and the extensive laboratory facilities available, make it possible to present a much more comprehensive program than would be possible in the field. It is often difficult, however, for personnel in the more distant states to obtain the necessary travel funds to

radiological health was included. A similar institute is being planned for the New England states during the summer of 1959.

Due to the ever-increasing demand for radiological health training assistance has been provided to a number of colleges and universities in the United States to establish programs in radiological health. In cooperation with the Pan American Sanitary Bureau, a course in water monitoring and radio-

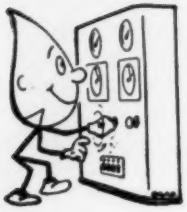
active waste disposal was presented in 1958 at the School of Sanitary Engineering of the University of Mexico, Mexico City. A series of similar courses was presented in West Germany in 1958.

Currently many laboratories are analyzing environmental samples for radioactive pollutants. To evaluate the methods and techniques used in such determinations the training program of an analytical reference service is conducted. This service distributes samples of specific composition to various member laboratories and by reviewing the analytical results and the methodologies employed methods of choice can be evolved. A water sample containing a known concentration of a single radioactive material was distributed during the latter part of 1958 to approximately 40 member laboratories. It is believed that the data reported on these samples will be of considerable significance in the evaluation of current water assay methodology. A similar sample has been distributed to eight radiological monitoring laboratories which are engaged in a study for a *Standard Methods* subcommittee of the Federation of Sewage and Industrial Wastes.

Summary

The demand for radiological health training is expanding. The number of persons receiving academic training in radiological health is far inadequate for present-day needs. In an effort to meet the acute shortage of personnel qualified in the fields of nuclear wastes and environmental surveillance USPHS conducts intensive, technical, short-term training courses. The courses described in this article are those particularly directed toward personnel responsible for water quality.

As to the personnel attending these courses, the diversity of professional affiliations (Table 2) represented is of particular interest. This illustrates, superficially at least, that many groups are taking active responsibility in protecting the quality of water from the radiation hazard. It is only through the mutual cooperation of these groups that the United States nuclear energy industry can expand with the assurance that the precious commodity, water, will be protected.



Concepts in Determining Potability of Water After Nuclear Attack

Gerhard Klein

A paper presented on Apr. 6, 1959, under the sponsorship of AWWA, at the Engineers Joint Council's Nuclear Eng. and Science Congress, Cleveland, Ohio, by Gerhard Klein, Asst. Director, San. Eng. Research Lab., and Assoc. Research Engr., Civil Defense Research Project, Univ. of California, Richmond, Calif.

THE number of publications that have appeared in recent years on the measurement and control of radioactive materials in water attests to the interest of workers in the water utility field in nuclear developments. An examination of this literature reveals that much emphasis has been placed on past and present problems, but hazards that may occur in the future have been relatively neglected. Maximum permissible concentrations (MPC) of radioisotopes for continuous lifelong intake in time of peace (*1*) and radioassay techniques for the measurement of radioisotopes at levels below these concentrations have been developed (*2*). These techniques have protected workers at or near atomic-energy establishments and the public at large from the internal radiation hazards resulting from the ingestion of contaminated water, which emanates primarily from large installations engaged in the manufacture and use of fissionable material. With the advent of nuclear research and the development of the power reactor, the possibility of accidental short-term intake of relatively large amounts of radioisotopes had to be considered.

Morgan and Ford (*3*) have proposed MPC levels based on single emergency exposures. The next step, the evaluation of MPC of radioisotopes in drinking water following test atomic explosions, is still in the process of formulation. This evaluation has begun with a compromise. Following recent nuclear weapons tests, radioactivity which exceeded published criteria by as much as several hundred times appeared in precipitation and in drinking-water reservoirs. The public was told by several official agencies that there was no reason for concern (*4*). The reason for this paradox was the inapplicability of the MPC set for continuous intake over a lifetime to concentrations which would diminish rapidly as a result of radioactive decay and dilution. The public's apprehension could probably have been allayed more successfully had the authorities been able to cite a rationally derived standard. Instead, they declared, more or less "intuitively" (but not necessarily any less properly), that the concentrations encountered were harmless. Such a standard is not presently available, however, for reasons which it is hoped this article will help to make clear.

The problem of establishing reliable MPC standards applicable to nuclear warfare is closely tied to the problems raised by fallout from nuclear bomb

tests. There are, nevertheless, significant differences between the fallout problems resulting from tests and those which would result from wartime nuclear explosions. After a test explosion, long-range fallout is of the greatest concern to public health officials. The concentrations of radioisotopes in water supplies remain fairly low and the tests are so conducted as to minimize fallout hazards. After a hostile nuclear attack, however, regions of local fallout would be likely to suffer from severe contamination, and the attacker could not be expected to minimize fallout hazards. The numerous publications dealing with long-range fallout, therefore, have no direct bearing on wartime contamination of the water supply.

In this discussion it will be shown: [1] that many assumptions are necessary in making predictions of fallout distribution and the resulting intensity and composition of radioactive drinking water contamination, [2] that the number and uncertainty of these assumptions make preattack estimates highly doubtful, [3] that emergency assays of water for specific isotopes will be desirable, and [4] how the formulation of safety criteria may be approached.

Origin and Fractionation of Contaminants

A brief description of phenomena associated with the explosion of nuclear weapons will be desirable in order to define basic concepts. This information is chiefly taken from a book edited by Glasstone (*5*).

The energy of a nuclear bomb is derived either from the fission or the fusion of atomic nuclei. The fission of uranium-235, uranium-238, or plutonium-239 causes the production of radioactive isotopes, which, with their decay products, are approximately 200 in number. The relative amount of these isotopes depends on the conditions during which the fission process takes place. Various computations of this amount have been made for the simultaneous slow-neutron fission of uranium-235. One of the most recent is by Low and Bjornstedt (*6*). The contribution of fission by fast neutrons in an atomic explosion is not readily observable. Neither is the actual composition of the fission products mixture resulting from such an explosion, because samples can only be taken at some distance from the explosion site, where interaction with the environment will have already modified the original composition. There are other obstacles. The dissemination of any firsthand knowledge collected during nuclear weapons tests is hindered, or at least retarded, by government security regulations. Also, the composition of the fissionable material constituting the weapon is usually kept classified. Even if the true spectrum of fission products composition were known for each fissionable species, therefore, the composite spectrum could not be ascertained.

The composition of a fission products mixture not only depends upon its formation but is also a function of time. Relatively small errors in the estimation of the original composition may result in large errors in a prediction of the composition at a later period.

The products of nuclear fusion are not expected directly to create a major radiological hazard. Fusion devices, however, must be triggered by an explosion produced by fission.

In addition to the source processes of radioisotopes, there are radioactive-explosive materials that, owing to the inefficiency of a nuclear detonation, do not participate in the reaction but are

dispersed by the explosion. Bomb components that are originally nonradioactive may become radioactive by bombardment by the neutrons freed by the detonation.

The neutrons released, especially those released by a fusion device, are also capable of rendering the air and terrestrial materials radioactive if the explosion takes place near the surface of the earth. The amount and composition of these radioactive materials are a function of the type and explosive power of the burst and the composition of the surrounding terrestrial material. The composition of all the radioactive material created is, therefore, evidently a complex function of the numerous conditions attending its origin. To assign to it the composition of the products of slow fission of uranium-235 is thus an approximation with obvious shortcomings. Nevertheless, it is probably the best approximation presently known, and its validity is strengthened by the following factors:

1. The fission products composition resulting from fast fission of uranium-235 may be similar to the composition resulting from slow fission.

2. Uranium-235 may be expected to be a predominant component of the explosive material used.

3. The contribution of the uranium or plutonium that has escaped fission will be relatively minor.

4. The induced radioactivity in the air is of little consequence.

5. Neutron capture by elements in the soil will produce radioisotopes of sodium of 15-hr half-life, and of manganese and silicon, both of only 3 hr half-life. None of these radioisotopes can constitute a long-term hazard.

6. Water itself will not become markedly radioactive by neutron capture and the activities induced in the dissolved solids will not persist long.

7. Originally nonradioactive components of the bomb that become radioactive may not make a significant contribution to the total mixture of isotopes.

The genesis of the contaminants is uncertain, as is their subsequent history. Nuclear explosions produce very high temperatures. Normally nonvolatile substances not only vaporize at these temperatures but even separate into a mixture of independent, elementary particles and form a socalled plasma. The reactions that occur when substances cool from this state have not been significantly investigated. Through such reactions vaporized radioactive materials probably condense and combine with the enormous masses of terrestrial debris which are sometimes drawn up in the wake of the rising fireball. This debris is itself probably melted, vaporized or otherwise modified by radiant heat, which would result in a number of undoubtedly very complex reactions. Even though these reactions are not understood in any detail, it is very probable that some components of the radioactive mixture condense less readily than others and are carried on by the winds. The more condensable portion descends to earth with the larger particles and constitutes the local fallout. This selective removal of some radioisotopes is called "fractionation." Fractionation may be expected to continue if there is any interaction of the fallout particulates with the environment, such as leaching during precipitation and percolation of the resulting solution through the soil, partial solution of particles that have fallen directly into water reservoirs, or sinking of larger particles. Fractionation may also take place in the treatment processes to which the water may eventually be subjected.

Tolerance Levels

It is apparent that any preattack estimates of the radiological contamination of drinking water will be uncertain. Tolerance concentrations have, therefore, been set up for gross activity (*7, 8*), which is relatively easy to measure accurately. These concentrations are given by Morgan and Straub (*8*):

$$\text{MPC} = 0.001t^{-1.2}\ \mu\text{c/ml}$$

where t is the time in days. The period of validity of this equation ranges from 30 min to 3 years after the explosion. Although neither the derivation of this equation nor the assumptions involved in the derivation are given by Morgan and Straub it is apparent that it applies to a fission products mixture of decay exponent 1.2. Morgan and Straub formulated this equation before the advent of the fusion bomb, however, and the contributions to radioactivity by the latter have, therefore, not been considered. Actually, the decay exponent even for a pure fission products mixture varies slightly with time and depends strongly on the composition of the mixture. Fractionation may, therefore, be expected to cause considerable variations from the value 1.2, and it has been shown to do so.

The rationality of this formula must also be considered. If the MPC value is too conservative, large amounts of water may be unnecessarily condemned during an emergency. Water, in the aggregate, is a resource of enormous economic value and may become vitally essential in a nuclear attack. If, on the other hand, the MPC value is too low, it may cause the ingestion by large segments of the population of water that is not sufficiently safe. The consequences of this could be catastrophic. Hence the importance of further study in this field.

The previous discussion is intended to show the need for a postattack radiochemical assay of drinking water. The subsequent discussion, which is based on a knowledge of the radiochemical composition of water, will further emphasize this need.

Radioactive material is ingested according to a certain regimen or schedule. In establishing the familiar peacetime MPC values for drinking water it is assumed that 2.2 liters of water containing a constant concentration of radioisotopes (expressed in microcuries per milliliter) are imbibed daily throughout many years, or even a lifetime. After a nuclear attack, the concentration of each isotope that has entered into the drinking water will vary in a characteristic manner with time. Although most isotopes will decay with their radioactive half-life, the amount of some others will initially increase for a short time after the explosion, because they are being continually formed by decay of their precursors.

In the body each isotope will distribute itself to various organs and build up concentrations there which are functions of time, depending on the intake regimen and the mechanism of the functioning of the organ. This process is taken as the basis for simplified mathematical models in which most organs are considered vessels with complete, instantaneous mixing. The gastrointestinal tract is compared to a tube through which the radioactive material passes in a sluglike manner (*3*). The retention of radioactivity in bones is described empirically by a power function (*9*). In practice these relationships are complicated by translocation of radioactivity from one organ to another and by deviations in the behavior of the organs from the model. In this article only the model based on complete, instantaneous mixing will be

considered, because it is most easily amenable to the mathematical formulas and serves best to illustrate some important points. The discussion will be confined to a single isotope.

The differential equation expressing the relationship between the amount x (in microcuries) of the isotope in the organ at time t (in days) and the intake rate $Be^{-\lambda_r t}$ (in microcuries per day) is given by:

$$\frac{dx}{dt} + \lambda x = Be^{-\lambda t} \quad \ldots\ldots (1)$$

where the effective decay constant is:

$$\lambda = \lambda_r + \lambda_b \quad \ldots\ldots (2)$$

and λ_r is the radioactive decay constant and λ_b the analogous biological decay constant, equal to the reciprocal of the effective detention period in the organ. The unit of these decay constants is day^{-1}; B is the daily intake at $t = 0$. Integration of Eq 3 yields:

$$x = \frac{B(e^{-\lambda_r t} - e^{-\lambda t})}{\lambda_b} \quad \ldots\ldots (3a)$$

where t is less than t_1, and

$$x = \frac{B(e^{-\lambda_r t} - e^{-\lambda t_1})e^{-\lambda(t-t_1)}}{\lambda_b} \quad \ldots (3b)$$

where t is greater than t_1. In Eq 3a and b, it is assumed that intake of the contaminated water into the organ begins at $t = 0$, and ends at $t = t_1$. The dose rate absorbed by the organ, in roentgen equivalents man (rem) per unit of time, is proportional to x (1 rem is the dose of any ionizing radiation that will produce the same effect, biologically, as is produced by 1 roentgen of high-voltage x-rays). Integration of Eq 3 yields the total absorbed dose multiplied by some constant, D (in roentgen equivalents man), to time, t. It results in an equation essentially identical to that given by Morgan, Snyder, and Ford (*10*):

$$\frac{D}{B} = \frac{1}{\lambda}\left(\frac{1 - e^{-\lambda_r t_1}}{\lambda_r} + \frac{e^{-\lambda t}(1 - e^{-\lambda_b t_1})}{\lambda_b}\right) \quad \ldots (4)$$

Thus Eq 3 and 4 furnish the basis for calculating the dose rate and the accumulated dose for an organ if the biological half-life for the isotope in question is known. Figure 1 schematically illustrates these functions for an isotope of $\lambda_r = \lambda_b = 0.01$ (corresponding to radioactive and biological half-lives of 69 days).

TABLE 1

Permissible Dose Rates for 50-Year Occupational Exposure

Organ	Maximum Permissible Dose Rate *rem/wk**	Integrated Dose *rem*
Bone	0.56	1,520
Thyroid or skin	0.6	1,630
Gonads or total body†	0.1	271
Other organs†	0.3	815

* Dose can be averaged over a 13-week period.
† Average dose to age N years not to exceed $5(N-18)$ rem.

Figure 1 shows that the dose rate reaches a peak and then subsides. The rate at which it subsides depends upon both the radioactive and the biological decay constants. Figure 2 is a functional scale used in the computations for Fig. 1. In order to establish the MPC for the radioisotope the maximum permissible dose rate per unit of time must be determined for various organs of the body. Table 1 shows suggested permissible dose rates, listed by Morgan (*11*), for 50-year occupational exposure.

Maximum permissible dose rates for emergency exposures probably exceed

those listed in Table 1. Inasmuch as an acute total body exposure to 25 roentgens of external radiation produces slight radiation sickness in only about 1 per cent of the population (*12*), this exposure, active over a relatively short period of time, perhaps 1 day, may be considered safe. Another factor is that radioisotopes tend to concentrate in certain organs of the body.

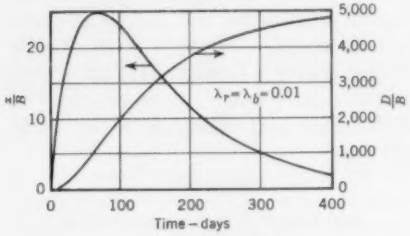


Fig. 1. Dose Rate and Dose Due to Continuing Ingestion of Decaying Radioisotope

A schematic diagram of the dose rate (arrow to left), calculated from Eq 3a, and accumulated dose (arrow to right), calculated from Eq 4. Instantaneous mixing in and exponential elimination from the organ is assumed. In plotting these values: x *is the amount of isotope present (in microcuries);* B *is the intake rate at time zero (in microcuries per day);* D *is proportional to the total absorbed dose (in rem);* λ_r *and* λ_b *are the radioactive and biological decay constants (in reciprocal days).*

Allowing these organs to be exposed to the maximum permissible extent would mean that the other parts of the body would be exposed to a lesser degree. It is well known that total body exposure to external radiation has far more severe consequences than partial exposure (*13*). It follows, therefore, that a maximum permissible exposure rate of 25 rem per day would probably be on the safe side for most organs. This would be equivalent to approximately 1 rem/hr as compared to 0.0025 rem/hr for the occupational lifetime exposure of the total body. It is obvious that the same standards cannot even approximately apply to occupational and civil defense emergency exposures.

Next, the accumulated dose given by Eq 4 and illustrated by the rising curve in Fig. 1 should be considered. Table 1 gives permissible cumulative, or integrated, doses for lifetime occupational exposure. These values may almost certainly be increased for emergency exposures because the resulting disabling and life-shortening effects will have to be viewed in perspective with other deleterious manifestations of a nuclear war.

After agreement on values for the maximum permissible absorbed dose rate and maximum permissible total dose it would only be necessary to calculate the MPC from Eq 3 and 4 and choose the smaller value as the applicable one. The difficulty is, however, that acute and chronic exposures blend into each other and that exhaustive experimental evaluation is impossible because of the great number of combinations that may occur. Nevertheless, this seems to be an area for fruitful research; judicious generalizations may limit the number of cases to be investigated. The armed forces have formulated dose criteria such as 15 rem in 90 days and 150 rem in 30 days (*14*). These criteria are certainly capable of rational refinement.

Another field of desirable experimentation would be the study of the synergistic action of radioisotopes in the body. Very little is known in this respect. In all formulations of MPC for drinking water during an emergency, the probable simultaneous inha-

lation of radioactive materials, the ingestion of radioactive food, and exposure of the body to external radiation will also have to be considered. The prevalence and action of these factors are of great uncertainty.

Summary

The ideas of this article may be summarized as follows:

1. Providing potable water as a vital resource following a nuclear attack will require the formulation of rational criteria for MPC of radioisotopes.

2. Concepts used in making such a formulation have been generally outlined. Definite criteria have been given by other authorities, but refinement is desirable.

3. The application of the criteria established would involve a preliminary specific radioassay of the water.

4. This article has described some of the specific areas in which further research is needed.

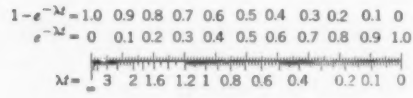


Fig. 2. Functional Scale

This scale is the basis of the computations for Fig. 1. It is useful in many dose criteria calculations.

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Assembly and Operation of a Low-Level Counting Facility

Byron M. Branson, G. R. Hagee, A. S. Goldin, Gerald J. Karches, and Conrad P. Straub

A paper presented on Apr. 6, 1959, under the sponsorship of AWWA, at the Engineers Joint Council's Nuclear Engineering and Science Congress, Cleveland, Ohio, by: Byron M. Branson, Physicist; G. R. Hagee, Chief, Physical and Instrumental Analysis; A. S. Goldin, Chief, Radiochemical Analysis; Gerald J. Karches, Physicist; and Conrad P. Straub, Chief, Radiological Health Research Activities; all of the Division of Radiological Health, Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

THE measurement of radioactivity in environmental samples of various types is becoming increasingly important. Although measurements of gross radioactivity provide preliminary information, definite assessment of the health significance must be based on a knowledge of the radionuclide content of these samples.

For some time, gross radioactivity of environmental samples has been measured at the Robert A. Taft Sanitary Engineering Center (*1–3*), the internal proportional counter being the primary measuring device (*4*). Some radionuclide determinations have been made through the utilization of chemical separations and a limited number of supplementary instrumental techniques. The need for radionuclide determinations was recognized, and consideration of a suitable program, based on an optimum combination of chemical and instrumental techniques, was started. In March 1957 work was begun to evaluate specialized instrumentation applicable to the determination of radionuclides at environmental levels.

The choice of different types of instruments to be added to the program was based on a number of factors, such as the types of nuclides and samples, levels of activity to be measured, and cost.

The selected equipment included a low-background (anticoincidence) beta-counting system, a liquid scintillation counter, primarily for the determination of H^3, and a gamma scintillation spectrometer with heavy shielding and a large crystal. The problems of housing such equipment and those of its operation should be of interest to others.

Location of Installation

Certain factors had to be considered in choosing a location for the facility: availability of space in the building, the natural shielding characteristics of the latter, and a floor strong enough to bear the weight of the equipment. The floor had to support seven of the 10 tons in an 18-sq ft area. A basement area of 225 sq ft, located against an outside wall three floors under the

surface of the ground and 35 ft from a second outside wall, was assigned to the project. The other two sides were essentially exposed to the outside, as the building is located on a steeply sloped hillside. To complete the room, two additional walls were built of concrete block with cement-filled cores to provide 8 in. of solid shielding for a height of 10 ft, except for the door, the vent fan, and necessary piping inlets. All services were brought into the room either at the corners, where the new walls joined the old, or next to the door and passbox.

An air conditioner was installed to handle heat from an estimated eventual electrical load of 8 kw. The air conditioner circulates and filters the air, thus minimizing radioactive contamination by particles in the air. An internal location was chosen so that no ducts penetrated the shielding. When needed, a manually controlled exhaust fan, installed at a height of 10 ft, vents stale air.

All the instruments are so arranged as to be remote from the door, the weakest point in the shielding. The beta-counting equipment is located in the corner that has the best natural shielding. For the small amount of cleaning and service necessary a work bench and sink were installed. A pass box was built into the door for receiving and dispensing samples, thus minimizing the dust and contamination that would be caused by traffic in and out of the room. Heat is provided by the instruments themselves and the air conditioner serves as the year-round temperature control.

The three-phase electrical supply is divided into three 110-v, 30-amp circuits. In addition to the neutral wire, each 110-v outlet includes a static ground through the conduit. Each of the three more sensitive instruments was connected to a different 110-v circuit. The air conditioner and lighting supplies were obtained separately, thus eliminating the introduction of line fluctuations and transients. Each piece of electronic equipment not equipped with built-in voltage regulators was supplied with constant-voltage transformers.*

Low-Background Beta Counter

The low-background beta counter † is a dual unit consisting of two thin-window, gas flow Geiger-Muller counters. The low background is achieved by a combination of choice of materials, an anticoincidence ring of Geiger tubes for elimination of cosmic ray background by electronic blanking, and steel shielding.

TABLE 1

Background Values of Low-Background Beta Counter

Size of Unit	Background—*cpm*		
	Taft Center Values	Manufacturer's Specification	Manufacturer's Values
2-in. detector	0.6	1.5	0.9
1-in. detector	0.3–0.4	1.0	0.5

The two central counters are constructed of low-radioactivity resin, with an aluminum-coated polyester film window 0.9 mg/sq cm thick. A resin container with a 1-in. wall of mercury separates the two counters, providing

* Type CVH Harmonic-Neutralized; a product of Sola Electric Co., Chicago, Ill.

† Model CE-14; a product of Tracerlab Inc., Richmond, Calif.

shielding for each counter against radiations from the sample in the other. Because the windows are not gas-tight, the counters operate with a continuous small flow of Geiger (helium–isobutane) gas.

Around the central counters are eleven Geiger tubes, 1×15 in. each, arranged in a semicylinder to detect any background radiation and black

instrument was equipped initially with two 1-in. window detectors. Recently 2-in. window detectors have become available, and one has been purchased and installed.

The system has been very stable and the measurements obtained are quite reproducible. The backgrounds are lower than the maximum of the specifications, and approximately one-third

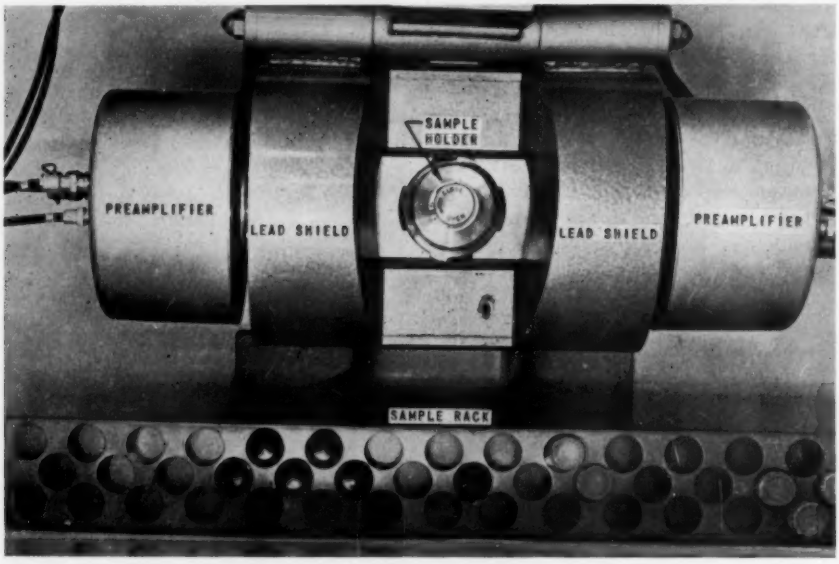

Fig. 1. Liquid Scintillation Spectrometer

This instrument, viewed here from above, is housed in a freezing unit. Two photomultiplier tubes view the sample and an electronic circuit records those coincident pulses that are registered by both tubes.

out any cosmic-ray event that triggers both a central counter and monitor detector (anticoincidence umbrella). The entire system, counters and umbrella, is surrounded by an 8-in. thick steel shield weighing 5,300 lb.

All electronic circuitry is housed in a standard relay rack 14 in. high. The counts from the counters and the umbrella are recorded individually. The

lower than the values obtained by the manufacturer (Table 1).

This system has been used primarily for counting Y^{90} to determine the Sr^{90} content of various environmental samples. With the sample $\frac{3}{4}$ in. below the window, the 2-in. detector has an efficiency of approximately 30 per cent and the 1-in. detector approximately 16 per cent.

Samples are usually counted for 100 min, divided into two 50-min periods so that statistical agreement can be checked. With this counting time, one disintegration per minute (dpm) of Y^{90} can be definitely detected, and 5 dpm can be measured with 25 per cent counting error (two standard deviations) with the 1-in. detector. With the 2-in. detector, sensitivity is 0.6 dpm and 5 dpm can be measured with 20 per cent counting error in the same time.

Liquid Scintillation Spectrometer

The chief function of the liquid scintillation spectrometer * (Fig. 1) is the counting of low-energy beta emitters, particularly H^3, which are not conveniently counted by other equipment. The sample, dissolved in a liquid scintillating solution, is viewed by two photomultiplier tubes. This assembly (including preamplifiers) is housed in a freezer unit. An electronic circuit records those (coincident) pulses that are registered by both tubes, and are within predetermined amplitude limits.

Although the internal sample has 4-pi geometry, it is not possible to operate the instrument with 100 per cent efficiency. Restrictions are imposed by the small light pulses produced, and by the need to discriminate against thermal noise from the phototubes. In counting H^3 betas, the light pulses are exceedingly small, owing to the low energy of this radiation and the rather poor scintillating properties of solutions containing water.

By recording only coincident pulses, the thermal-noise background is markedly reduced, because pulses of this type, originating independently in each tube, do not often occur simultaneously in two tubes. Operation at low temperature reduces the number of thermal emissions in each tube and thus further reduces the background. The detected pulse, in circuits which follow, can be categorized according to its energy because the unit is also a two-channel analyzer.

The application of this system to the measurement of beta emitters of differing energy can be seen in Fig. 2. Although high voltage is varied in successive steps and measurements made, the discrimination settings of the instrument have been held fixed. The relative activities, when plotted as a function of voltage with fixed discriminator settings, have the shapes shown, the higher-energy emitters reaching a maximum at low-voltage settings and conversely. Thus, for a mixture of two nuclides widely separated in energy, optimum count rates could be

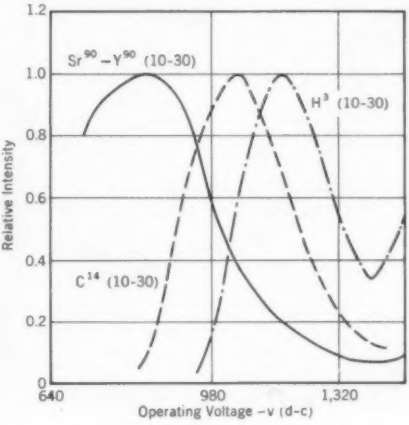

Fig. 2. Relative Intensity as a Function of Operating Voltage, Liquid Scintillation Spectrometer

By proper selection of discriminator settings, optimum count rates can be obtained for each nuclide.

* Model No. 314; a product of Packard Instrument Co., LaGrange, Ill.

obtained for each by proper adjustment of operating voltage and discriminator setting.

The liquid scintillation spectrometer is employed at present in measuring H^3 in water samples. Efficiencies of 2–3 per cent are obtained for this nuclide through the use of 4 ml of sample in 16 ml of "611" scintillator (*8*). With 1,000-min measurements, the sensitivity for this nuclide is about 10 $\mu\mu$c/ml.

Compton ratio, the latter minimizing the correction for the effect of nuclides of higher energy. To permit use of large samples and to reduce the back-scatter the sample space had to be large.

A specially designed 4-ton shield built locally provides 6 in. of steel shielding surrounding an interior space 18×18×24 in. high, shown in Fig. 3. For convenience in use it is elevated 2 ft off the floor by 4-in. steel pipe

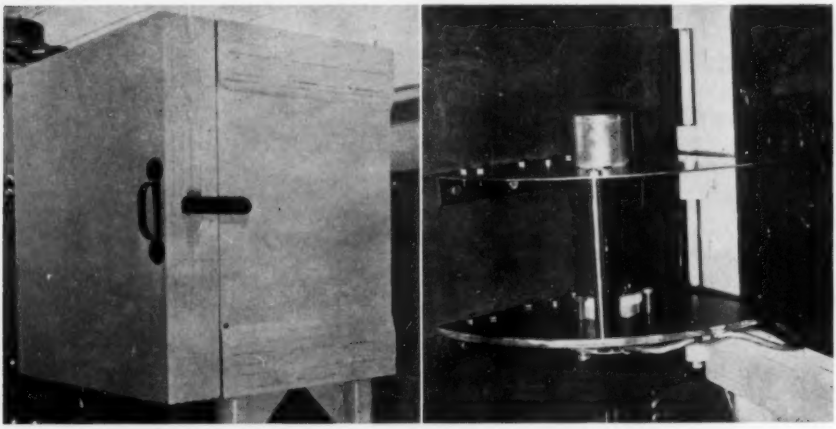

Fig. 3. Low-Level Gamma Spectrometer and Housing

The sodium iodide crystal and photomultiplier tube (right photo) are housed in the 4-ton steel shield (left photo). Mounting the equipment on the door has made service and accessibility easier.

Low-Level Gamma Spectrometer

The low-level gamma system consists of a 100-channel pulse height analyzer,* and a 4×4-in. sodium iodide crystal and 5-in. photomultiplier tube † housed in a massive, steel shield. A large crystal was chosen for maximum detection efficiency and maximum peak

legs. The walls are laminated of six 1-in. steel plates welded together. The door, weighing about 1 ton, is full face, thus minimizing penetration of stray radiation and simplifying construction. It is supported by three large strap hinges and can be operated easily by women technicians.

An important problem in building such a massive steel shield is the presence of radioactive contamination on the shielding itself. The steel, which

* Model 3300; a product of Radiation Instrument Development Corp., Chicago, Ill.

† Model 6364, Allen B. DuMont Laboratories, Inc., Clifton, N.J.

was obtained from surplus stock, was rusty from exposure. Gamma spectral analysis of this rust showed contamination with fission product activity, especially zirconium-niobium, ruthenium, and cerium. Therefore, before construction all the steel plates were sandblasted to remove both rust and contamination. Chips from drilled holes, checked by gamma spectral analysis, showed no gamma radioactivity in the steel itself.

The 4×4-in. solid sodium iodide (thallium-activated) crystal is hermetically sealed in electrolytic copper with a quartz glass window. The 5-in. photomultiplier tube is ideally suited to a 4-in. crystal, as its photocathode is $4\frac{1}{4}$ in. in diameter. The crystal was attached to the top shelf and the tube brought into contact with the crystal window, with a silicone fluid as an optical couple. The photomultiplier socket assembly contains the voltage dividers and a cathode follower output. All of the power for this detector is supplied from the analyzer.

Mounting this equipment on the door (Fig. 3) has made service and accessibility easier, and also provides a simple method for sample presentation. As many of the samples analyzed are bulky, a series of special aluminum beakers (Fig. 4) were designed for maximum geometry (*5*). With the crystal exposed by opening the door, these and other samples can be positioned very readily.

In addition to the special aluminum beakers, polyethylene containers are commonly used for smaller samples, because they are unbreakable and acid-resistant and have no detectable radioactivity.

To eliminate the possibility of mechanical shock to the detector when the door is closed, a snubber was installed in the shield. A strippable plastic coating allows for easy decontamination of the shield in the event of an accident.

Figure 5 shows a typical background spectrum. The peak observed at about 1.40 Mev is due to the K^{40} in the glass of the tube. The peak at about 0.5 Mev is attributed to positron capture (*6*), and the 0.14-Mev peak is caused

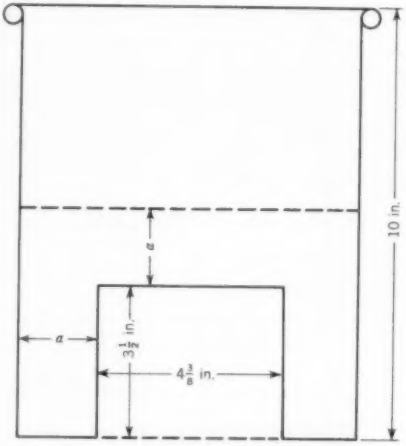

Fig. 4. Aluminum Beakers for Sample Presentation

These beakers, having maximum geometry, were designed in three sizes: 1, 2, and 3.5 liters, in which a *is* ¾, 1⅛, *and* 1⅞ *in., respectively.*

by a combination of low-energy gamma radiation and backscatter. The background has been stable over a 4-month period, which indicates no residual fission product contamination.

The highest background with the shielded 4×4-in. crystal is about 22 cpm at 0.14 Mev.* A 2×2-in. crystal, with 2 in. of lead shielding, has a background at this energy level of 12

* Per 20-kev channel.

cpm. Thus, the larger crystal, with eight times the volume and a correspondingly high efficiency, has slightly less than twice the background. This combination makes it a very useful analytical tool for samples of low activity.

By the addition of a thin lead liner inside the steel shield (*7*), the background at low energies can be reduced substantially. This is a refinement planned for the very near future.

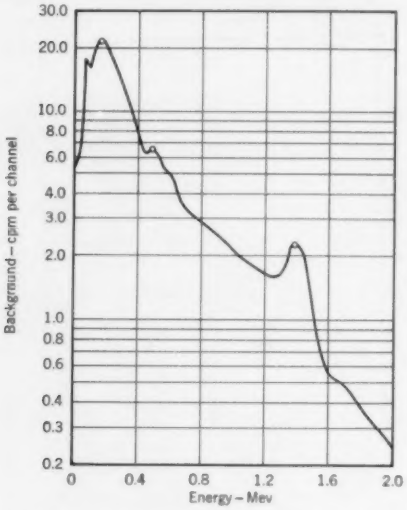

Fig. 5. Background Spectrum for Low-Level Gamma Spectrometer

The duration of counting was 1,000 min. The background activity of the instrument has been stable for more than 4 months. The background data are per 20-kev channel.

Some calibrations have been made with samples placed inside the special 3.5-liter beakers and in 2-in. sample dishes. Table 2 shows some of these values. As a result of these calibrations, I^{131}, Cs^{137}, K^{40}, and Ba–La^{140} can be determined simultaneously in milk without chemical processing and with consequent saving in instrument time. With I^{131} this is particularly important as there is no satisfactory separation process for liter quantities.

For many other environmental samples, the system is being used for qualitative analysis of gamma-emitting nuclides. Calibrations are under way to extend the usefulness of this system to additional quantitative applications.

This detector and the 100-channel analyzer are in essentially constant use. Although some samples are sufficiently active that measurements of 5–15 min are adequate, most samples are near background activity and hence are counted for 100 min for more accurate data. A few samples are measured for 1,000 min, and occasionally measurements of 4,000 min have been made for special samples or stability studies. Usually, the analyzer is set up to cover the range 0–2 Mev, which detects most gamma-emitting nuclides found in environmental samples. For special problems, such as the identification of Co^{60} by its "sum" peak at 2.50 Mev, a range of 0–4 Mev is used.

Gamma Spectrometer and 2-in. NaI Detectors

This system utilizes 2-in. solid or well-type sodium iodide (thallium) crystals attached to photomultiplier tubes with a 20-channel pulse height analyzer.* Each detector is housed in a 2-in. thick lead shield designed and built at the laboratory (Fig. 6). As circuitry and cabling of all gamma spectroscopy components have been standardized, connection can be made to any pulse height analyzer within minutes. This permits substitutions when either analyzer is inoperative.

* Model 520M; a product of Baird-Atomic, Inc., Cambridge, Mass.

Because this analyzer is best used to cover 20 per cent of the energy range of the 100-channel analyzer, it is used primarily for detection of an individual nuclide. Because of its good geometry, the well detector is particularly suited to measurement of samples in test tubes.

Internal Proportional Counters

Two internal proportional counters with lead shielding * in this room have a beta–gamma background about 33 per cent less than that observed on similar counters located on upper floors of the same building. This instrument has been discussed adequately elsewhere (*4*).

TABLE 2

Efficiency Calibrations for Four Nuclides, 3.5-Liter Beakers

Nuclide	Energy *Mev*	Efficiency* *per cent*
I^{131}	0.36	9.2
Cs^{137}	0.66	4.7
K^{40}	1.40	2.7
$Ba–La^{140}$	1.60	1.7

* Based on integrated total count (counts per minute per gamma disintegrations per minute) under the photopeak.

Moisture

A breakdown of the low-level gamma spectrometer system after approximately a month of operation was traced to condensation. Over long measurement periods with the shield closed, aqueous samples evaporate considerably, the vapor condensing on the entire inner surface of the shield, on the photomultiplier tube, and inside the cathode-follower unit. This resulted in sufficient corrosion within the preamplifier to require rebuilding.

To overcome this difficulty, the surface of the beaker is covered tightly with aluminum foil whenever liquid samples are counted. In addition, a desiccant is provided inside the preamplifier housing, and is replaced every 2–3 weeks. The possibility of a hermetic seal for the preamplifier, which should eliminate the need for desiccant, is being investigated.

The internal proportional counters have transistorized preamplifier units. As heat dissipation is small, moisture and dust accumulate on certain critical capacitors. The resulting electrical leakage causes unstable background counting. Whenever this difficulty occurs, the critical capacitors must be thoroughly cleaned, and coated with silicone grease prior to replacement. Use of the silicone has reduced, but not eliminated, this problem.

Contamination

As this facility was designed for samples with extremely low activity, it is necessary to control radioactive contamination. The ventilation system brings in a minimum of outside air and provides continuous filtration of room air. As fallout could be brought in on street shoes, all personnel entering the area are required to wear shoe covers provided at the entrance. As an added precaution laboratory coats worn in other areas are not permitted in this room.

A gamma spectrum (Fig. 7) was obtained with the low-level spectrometer from the shoe covers worn in this area over a 2-day period. Photopeaks characteristic of zirconium-niobium, ruthenium, and cerium are readily seen, which indicates that fission product ac-

* Model PCC-11-A; a product of Nuclear Measurements Corp., Indianapolis, Ind.

Fig. 6. Two-Inch Sodium Iodide Detectors

The two 2-in. thick lead shields were designed at the laboratory. Connection can be made to any pulse height analyzer, as all circuitry and cables used in gamma spectroscopy have been standardized.

tivity is associated with the particulate matter present.

Lighting

Fluorescent lighting had already been installed when construction of the counting facility began. In liquid scintillation counting, this offered a potential source of difficulty when glass vials were used (*8*). On exposure to fluorescent illumination glass becomes phosphorescent, emitting light readily detected by the photomultiplier tubes. This emission persists for a number of minutes after exposure, and thus contributes an irregular error in counting. Tests on empty vials showed that this problem was significant. As incandescent lighting cannot cause this phenomenon, the fluorescent lighting was replaced.

Resolution of Low-Level Spectrometer

The large crystal detector initially had resolution (for the Cs^{137} 0.661-Mev line) of approximately 14 per cent. Attempts to improve this by remounting the crystal, both on the same and on similar photomultiplier tubes, failed. Resolution deteriorated to about 17 per cent over the next 2–3 weeks. The crystal was returned to the manufacturer for examination. A leak was found in the hermetic seal which permitted moisture to enter, with consequent discoloration around the periphery of the crystal. After being repolished and recanned, the crystal had a resolution for the 0.661-Mev line of 9 per cent or less.

It was found in early work with large-volume sources that known photopeaks were shifted to a lower

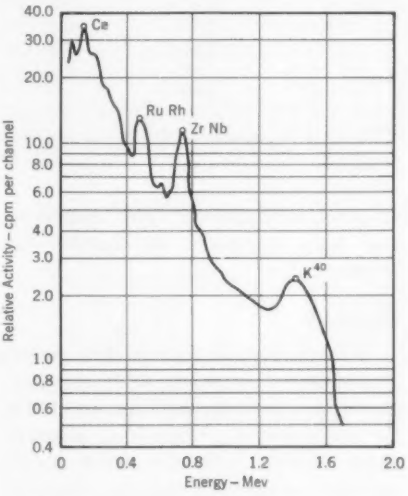

Fig. 7. Gamma Spectrum of Plastic Shoe Covers

This spectrum, based on data from the low-level spectrometer, was taken from shoe covers worn in the counting area for 2 days. Channels were 20 kev.

channel, compared with calibration with a centrally located point source. These variations in peak location depend on source location relative to the crystal, as shown in Fig. 8. This figure shows the peak channels of a point source of Cs^{137} in various locations around the crystal, the extremes of photopeak location differing by about 5 per cent. Whether this is due predominantly to photocathode nonuniformity in the photomultiplier tube or to some nonuniformity in the crystal is not known. This shift is being compensated for by appropriate adjustment of the photopeak channel of a point source so that photopeaks of extended sources will occur in the desired channels.

High-Frequency Transients

Unpredictable bursts of counts were noted to occur simultaneously in the liquid scintillation counter and pulse height analyzers. These bursts occurred even when the detectors were disconnected from the analyzers. Studies indicated that the problem was in the a-c line. Oscilloscope traces showed high-frequency transients superimposed on the a-c sine wave. Units equipped with harmonic-neutralized, constant-voltage transformers were not affected, although the high-frequency disturbance was observed in the line preceding the transformers. Installation of high-frequency filter chokes * at the power input of each instrument solved the problem. These filters, although intended to prevent introduction of high-frequency disturbances into the a-c line by the instruments, in this case serve for the reverse purpose as well.

* Type No. FLO-119-2; a product of Gudeman Co., Chicago, Ill.

Malfunction and Service

A certain amount of instrument malfunction must be expected, and downtime is estimated to be about 15 per cent for the analyzers. The services of an expert electronic technician are essential to a program employing equipment of this complexity.

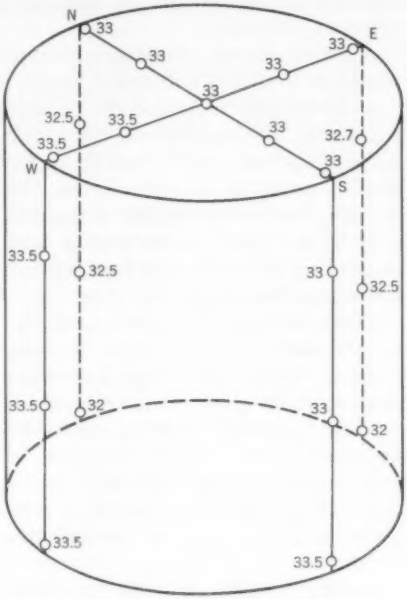

Fig. 8. Peak Channel Location as a Function of Point Source Location, Cs^{137}

In work with the low-level spectrometer using large-volume sources, it was found that photopeaks shifted to lower channels owing to variations in source location relative to the crystal detector. This shift may be compensated for by appropriate adjustment of the analyzer.

Summary

In the establishment of a counting facility of the type described in this

article, a number of factors must be considered:

1. The heavy shielding required for certain instruments limits site location to a floor having a high load-bearing capacity.

2. Shielding materials must be checked for radioactive contaminants prior to fabrication.

3. Adequate air conditioning is required to dissipate instrument heat.

4. Harmonic-compensated voltage regulators, or conventional regulators in conjunction with high-frequency filters, serve to provide stable line voltage, free of undesirable transients.

5. Shoe covers, restriction of traffic, and air filtration maintain freedom from airborne radioactive dust.

Other problems that arose during assembly and initial operation included moisture from liquid samples, phosphoresence of glass vials after exposure to fluorescent lighting, and variation in pulse height response of gamma spectrometers with the size and geometry of sample. Corrections were made in the course of studies that followed.

Stability both of the low-level gamma spectrometer and the low-background beta counter over extended counts of 1,000–4,000 min and from month to month in background measurements has been quite good. The long-term stability of the liquid scintillation system has not yet been determined. Down-time of the equipment is estimated at 15 per cent or less.

The sensitivities of the low-background beta counter, the liquid scintillation spectrometer, and the low-level gamma spectrometer have exceeded expectations.

Determination and identification of environmental radionuclides have been extended to very low levels in this facility, and information is being provided for the evaluation of their public health significance.

Acknowledgment

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Radioactive Contamination of the Environment in the Cincinnati Area

Lloyd R. Setter and Helen H. Russell

A paper presented on Mar. 12, 1958, at the Kansas Section Meeting, Salina, Kan., by Lloyd R. Setter, Chief, and Helen H. Russell, Chemist, both of Radiological Investigations, Radiological Health Research Activities, Robert A. Taft San. Eng. Center, USPHS, Cincinnati, Ohio.

IONIZING radiation of all types is harmful to living tissue. Because of this, and in the absence of a thorough understanding of the ultimate detrimental effects, the National Academy of Sciences (*1*) and the Medical Research Council, Great Britain (*2*), have suggested that all possible efforts be made to keep the levels of radiation as low as possible.

Sources of Contamination

In coping with the problem of radioactive contamination of water, it is important to locate potential sources of radioactivity. The more important man-made sources are wastes from: use of radioisotopes in industry, medicine, and research institutions; mining and chemical processing of uranium ore; nuclear reactors for power production or research; chemical processing of spent reactor elements for the recovery of nuclear fuel; fallout due to testing nuclear devices. Information pertaining to the location of these sources in a particular area is made known to state boards of health through AEC licensing requirements or in semiannual AEC reports.

The deposition of debris from nuclear devices is world-wide, but it varies in intensity depending on the type of device tested, the location, height, and topography of the detonation site, and the prevailing weather conditions. The congressional hearings before the Joint Committee on Atomic Energy (*3*) provide an excellent reference dealing with what is or is not known about fallout.

AEC, usually in conjunction with other federal and foreign agencies, operates various networks to define the fallout problem. For example, Lamont Laboratories in New York City receives samples of human and animal bone from all over the world for strontium-90 assay (*4*). The health and safety laboratory of the AEC, in cooperation with the US Department of Agriculture and other agencies, receives milk, vegetation, soil, and fallout samples from many states and countries (*5*). The US Weather Bureau and AEC contractors collect fallout samples from 92 and 11 stations, respectively.

USPHS conducts the National Radiation Surveillance Network, an offsite monitoring program, for AEC. This consists of 39 stations which submit daily filter samples for radioactivity assay, particularly during nuclear

weapons testing operations. Some of these stations also submit rain samples for assay.

The USPHS Robert A. Taft Sanitary Engineering Center, Cincinnati, in cooperation with state and municipal agencies, operates three national networks:

1. The National Air Pollution Network consists of 114 urban and 47 nonurban stations from which 24-hr samples of air particulates are collected at least once every 2 weeks for tests, including the measurement of radioactivity.

2. In the Basic Data Water Quality Network, weekly water samples from the principal United States streams are collected from 40 stations for gross beta and, in some cases, alpha assays.

3. The Milk Network was begun in 1957. Currently, five stations submit samples on a monthly basis and five more will soon be added to the network.

Station 5-4 of the National Radiation Surveillance Network at Cincinnati is in continuous operation. Daily and weekend samples are collected there and are assayed for natural alpha (radon daughter) and beta (nuclear debris) activity of air particulates.

This array of networks operated by federal agencies is supplemented by a few independent but comprehensive programs organized by some states and a few municipalities. The participation of many more states and local agencies will be essential to evaluate the effects of radioactive contaminants on a complex agrarian community. For instance, the assumption that there is a threefold variation in the "effective" fallout over the United States (*6*) is a rough guess based on little factual information.

Several groups are studying the strontium-90 content of water, soil, vegetation, milk, bone, and other matter. Strontium-90 is the most hazardous fission product radionuclide when inhaled or ingested because it is a bone seeker. The radiation of strontium-90 and its daughter, yttrium, may adversely affect the development of blood cells in bone marrow. Consequently, the maximum permissible whole-body exposure for the general public in unrestricted areas has been set at 30 mrem per week (*7*). It is estimated that the continuous use of drinking water that contains 80 $\mu\mu$c/l of strontium-90 and is the sole source of radiation exposure, other than background, will yield a maximum permissible exposure to bone tissue (*8*).

The suggested maximum permissible interim level in water for unknown radioisotopes is 100 $\mu\mu$c/l (*8*). This does not mean that a water with more than this level is necessarily hazardous, but it does mean that a knowledge of the composition of the important radioisotopes should be determined in order to evaluate the hazard.

For five successive years (as of March 1958) measurements of the gross beta radioactivity of precipitation (rain and snow) and of atmospheric particulates have continued at Cincinnati.

Testing and Sampling

A number of different methods were used in testing for radioactive contamination in the Cincinnati area.

1. *Fallout.* A rain collector, 0.09 sq m in area, located on the roof of the fourth floor of the Taft Center was used routinely in 1956 (*9*) and until Jun. 13, 1957. A tray collector, 1×2 m, and 12 cm deep, was then used to

collect large samples suitable for radiochemical and gamma spectral analyses in addition to gross beta measurements. The tray collector was placed on the library roof, which is fairly close to ground elevation.

Two polyethylene wastebaskets, each having a collection area of 0.03 sq m, were placed in service on Jun. 13, 1957, to collect composite semimonthly samples of fallout. One was located near the tray collector and the other replaced the routine 1956 rain collector. The purpose of these two collectors was to determine whether position and height above ground level influenced collection efficiency and whether semimonthly collections would be a reliable and practical method for determining fallout.

Rain and cistern samples were usually separated by membrane filtration into suspended and dissolved fractions and counted in internal proportional counters (*9, 10*).

Decay measurements of the more significant rainfalls were made periodically until the counting rate became unreliable (twice the instrument background). The counting rate was extrapolated to the day of collection. The decay rate established from a previous rainfall was used to extrapolate samples of very low initial counting rate.

2. *Cistern water.* The tap water from the cistern supplies of six individuals living within 15 mi of the Taft Center was sampled and tested with regularity in 1957. Samples from one to six of these cisterns were tested each time. During periods of high fallout as many as three samples were collected per month from each cistern.

3. *Surface water.* The tests of the beta activity in local streams by the Ohio Board of Health were made available for a comparison with Cincinnati rainout.

4. *Air particulates.* Air sampling through membrane filters was continuous, with daily or weekend collections.

Fallout and Air Activity

The 1957 beta activity of airborne particulate matter (in units of micromicrocuries per cubic meter), the suspended and dissolved beta activity of precipitation (chiefly rain) or the total dry (dust) fallout, and the US Weather Bureau local climatological report of precipitation for the Ault Park or Lunken Airport stations (the latter was placed in service on Jun. 1, 1957) are shown in Fig. 1.

The data in Fig. 1a for the first 4 months of 1957 show a moderately low level of air activity. Most activity was less than 8 $\mu\mu$c/cu m and the majority was less than 4 $\mu\mu$c/cu m. The rainout was generally low, as of the date of collection, and most of it was 1–3 months old, and, therefore, had a low decay rate. The exception was the relatively high rainout of 65 mμc/sq m on Apr. 18, which was identified as 17-day-old activity. The high air activity (16 $\mu\mu$c/cu m) on Apr. 26 resulted in an insignificant dry fallout (dustout). The dustout on Apr. 19 was also insignificant, even though it was preceded by a high rainout on Apr. 18. The "dry" fallouts on Feb. 8, Mar. 9–12, and Apr. 20–22, although low in relation to rainout, each included traces of rain.

The results of the next 4 months (May–August) in Fig. 1b show the period of high rainout due to United States nuclear tests after Jun. 10. The rainout in the September–December period (Fig. 1c) was relatively low

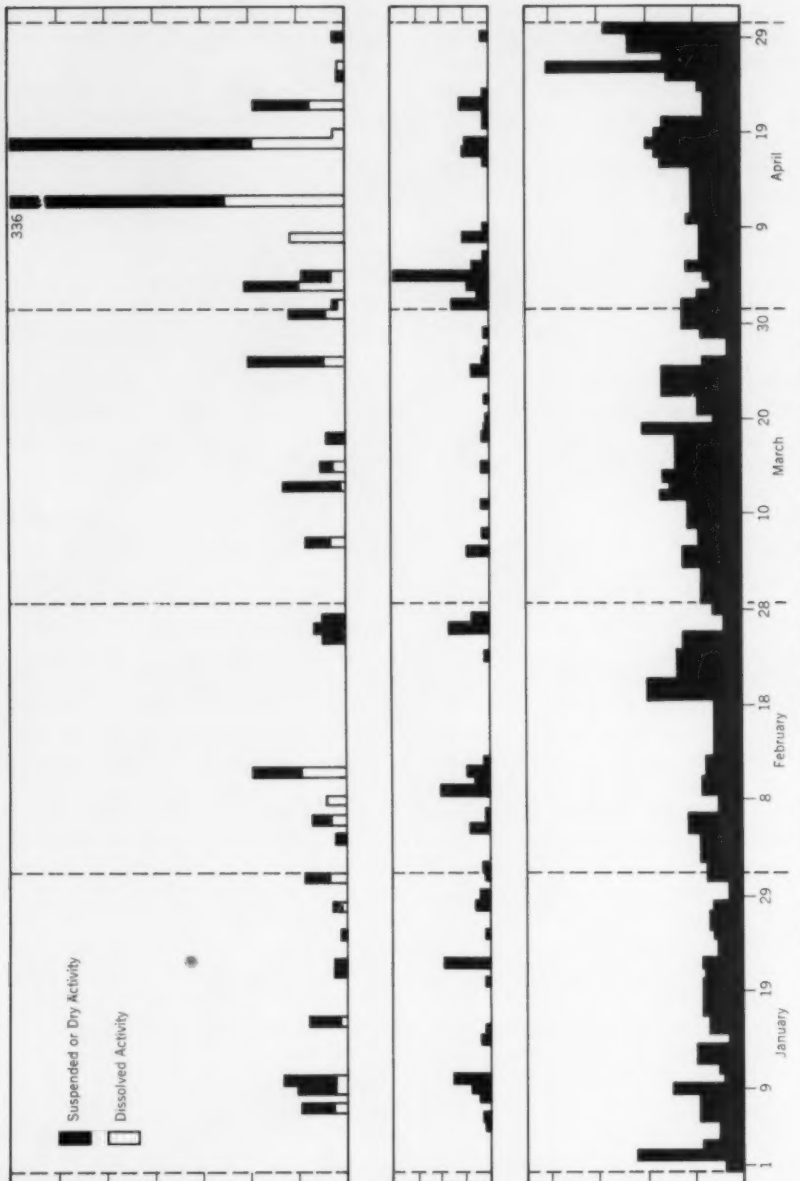

Fig. 1a. Nuclear Activity and Precipitation, January–April 1957

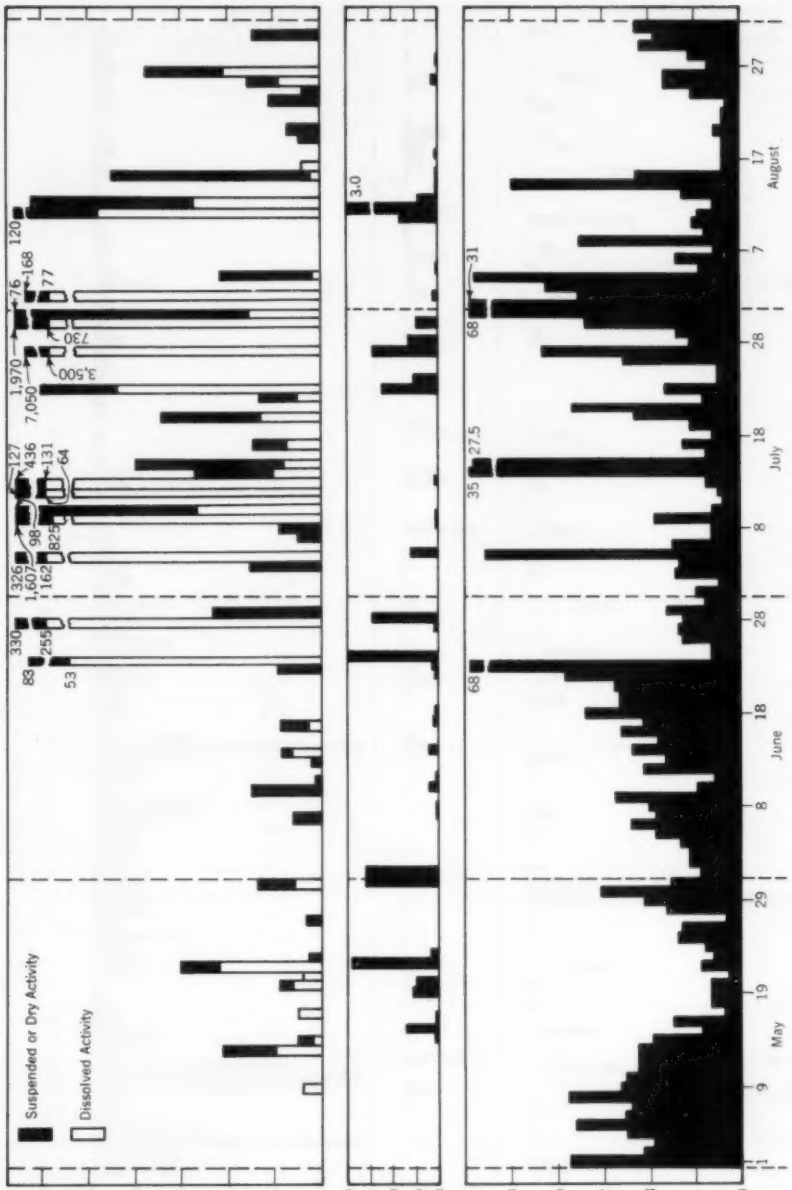

Fig. 1b. Nuclear Activity and Precipitation, May–August 1957

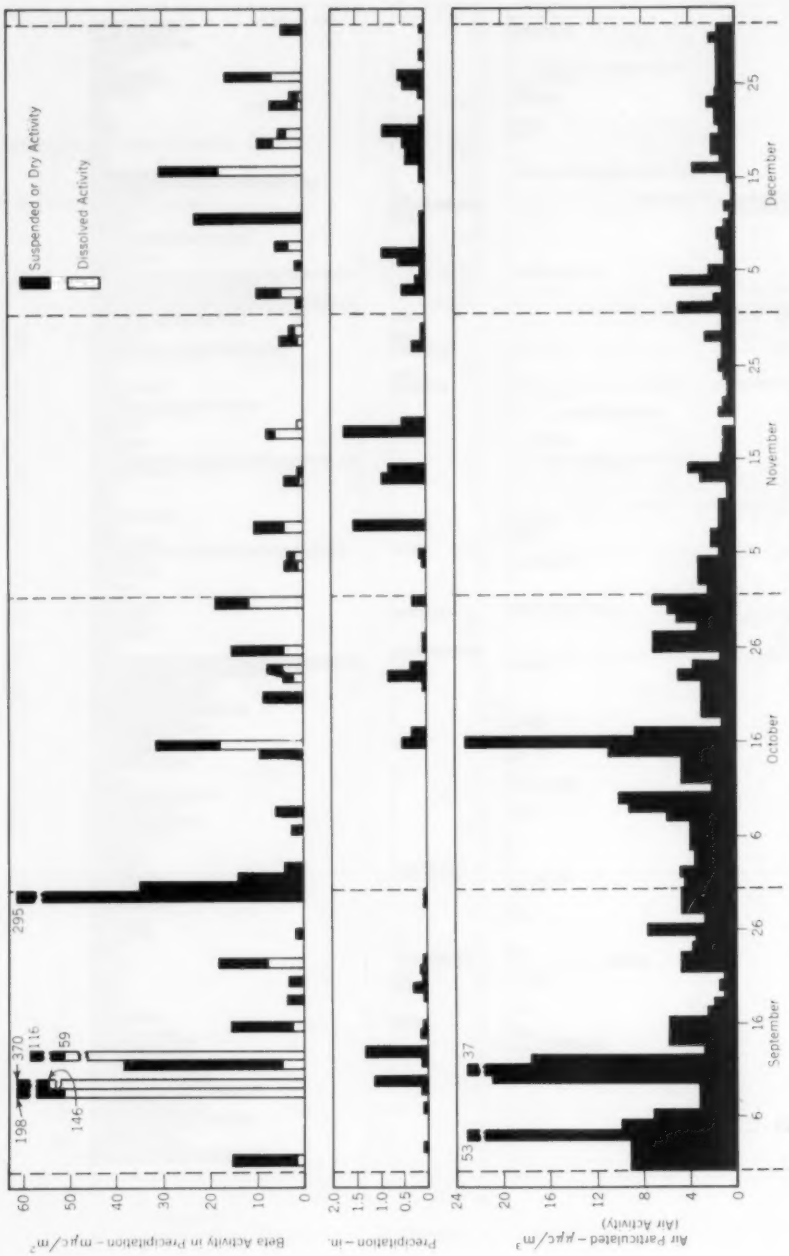

Fig. 1c. Nuclear Activity and Precipitation, September–December 1957

and was due to both United States and foreign nuclear testing, as indicated by the decay data summarized in Table 1.

It is significant to observe that high airborne particulate activity at ground level is not a criterion of high fallout. For instance, the high air activities of 68 and 53 $\mu\mu$c/cu m on Jun. 23 (Fig. 1b) and Sep. 4 (Fig. 1c), respectively, resulted in relatively little dry fallout. On the other hand, a 2-in. rainfall resulted in 7,050 $\mu\mu$c/sq m of rainout on Jul. 27 and 28 when the air activity was only 17 and 4 $\mu\mu$c/cu m, respectively. Similarly, a rainfall of about 0.5-in. on Jul. 5 resulted in a rainout of 326 mμc/sq m when the surface air activity was 22 $\mu\mu$c/cu m, and a 3-day rainfall of more than 3 in. on Aug. 10, 11, and 12 resulted in rainout of

TABLE 1

Rainout Decay

Period 1957	Assumed Date of Formation 1957	Negative Exponential Decay Rate*		
		Suspended	Dissolved	Total
Jan. 1–Mar. 14	Nov. 17†	0.9 –1.15	1.2 –0.8	
Mar. 15–Apr. 2	Jan. 1	1.0 –1.08	1.25–1.0	
Apr. 5–8	Jan. 19 & Feb. 20			1.2
Apr. 12–Jun. 7	Apr. 1	0.98–1.24	1.3 –1.18	
Jun. 10	May 23	1.24		
Jun. 13–19	May 15	0.86–1.0	1.13–0.86	
Jun. 23–25	Jun. 12	1.06–1.3	1.16–0.9	
Jun. 28–Jul. 8	Jun. 24	0.72–1.15	1.3 –1.04	
Jul. 7	Jun. 12			1.18
Jul. 9–23‡	Jul. 5	0.85–1.39	1.26–0.78	
Jul. 13	Jul. 11	1.18	1.0	
Jul. 27	Jul. 23			1.2
Jul. 30–31	Jul. 28	1.04–1.05	1.0 –0.93	
Aug. 1–25	Jul. 25	0.96–1.4	1.17–0.86	
Aug. 19	Jul. 15			1.05
Sep. 2	Aug. 18	1.25	1.02	
Sep. 9–12	Sep. 6	1.0 –1.18	1.07–0.97	
Sep. 13–19	Aug. 31	0.93–1.45	1.15–0.93	
Sep. 23	Sep. 6	1.05	1.25	
Sep. 30	Sep. 28			1.12
Oct. 2–7	Sep. 28			0.95–1.08
Oct. 9–16	Oct. 6	1.0 –1.17	1.28–1.08	
Oct. 21–23	Sep. 23			1.02–1.11
Oct. 26	Sep. 30	1.18	1.05	
Nov. 1–5	Oct. 6	0.77–0.9	0.89–0.83	
Nov. 7	Sep. 23	1.18		
Nov. 18	Sep. 30		1.04	
Dec. 3	Nov. 15	0.96		
Dec. 11	Dec. 7			1.2

* The decrease with time of the number of atoms of radioactive species, provided the number is large, is governed by the law:

$$N = N_0 e^{-\lambda t}$$

where: N is number of atoms present at time t, N_0 is number of atoms present at time zero, and λ is decay constant.

† 1956.

‡ Six rain and four dust collections.

192 mμc/sq m when the air activity was from 2 to 4 μμc/cu m. It should be noted again that "dry" fallout represents a relatively insignificant contribution to total deposition.

The individual depositions in Fig. 1 were extrapolated from decay data shown in Table 1 and accumulated to obtain the monthly deposition as of the day collected and as of the first of

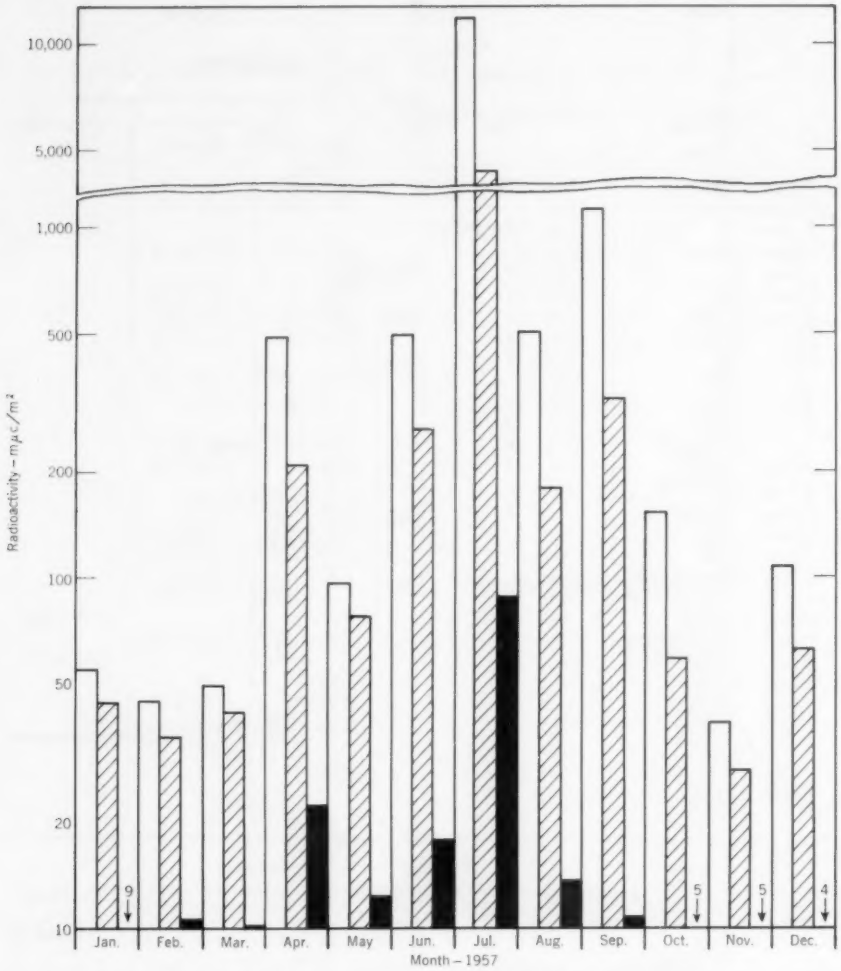

Fig. 2. Monthly Deposition of Radioactive Matter, 1957

The data were extrapolated from Table 1 and accumulated to obtain monthly deposition as of day collected (white) and the first of the month following deposition (lined). Black bars represent totals of 1-year-old activity.

the month following deposition, and the total amount of 1-year-old activity. The monthly depositions are shown in Fig. 2. The months of greatest deposition of 1-year-old activity were July, April, June, August, May, and September, in that order. The order for months of greatest deposition as of the day collected or the first of the month following deposition is different because of the age of the fallout. The deposition in July, August, and September was of relatively young rapidly decaying bomb debris as compared to the January, February, and March deposition. The annual fallout, as of the first of the month following deposition, was 5,600 mμc/sq m, of which 75 per cent fell in July. The annual 1-year-old fallout was 200 mμc/sq m, of which 42 per cent fell in July.

The monthly fallout of 1-year-old activity, separated into soluble and insoluble fractions by membrane filtrations, is shown in Fig. 3. The average monthly soluble activity in rain varied from 20 to 65 μμc/l, except in July when it was 330 μμc/l. The total activity varied from 35 to 320 μμc/l, except in July when it was 705 μμc/l. The annual fallout of 200 mμc/sq m in the annual precipitation of 50 in. amounts to a weighted concentration of 170 μμc/l. The annual average of dissolved activity was 66 μμc/l, or 40 per cent of the total.

Bolles and Ballou (*11*) have reported the abundance of radionuclides at various times after the fission of U^{235}. For 1-year-old fission products the per cent abundance values are: Ce^{144}, 25; Zr^{95}, 7.1; Pm^{147}, 6.3; Y^{91}, 3.95; Ru^{106}, 2.4; Sr^{90}, 2.3; Cs^{137}, 1.45; Sn^{123}, 0.7; Ru^{103}, 0.53; and Ce^{141}, 0.3. All the products except Pm^{147}, Y^{91}, and Sn^{123} have daughters in substantially equal abundance. Of particular significance is the strontium-90 abundance of 2.3 per cent. The maximum permissible concentration for this isotope in unrestricted areas is 80 μμc/l (*7*). To compensate for possible underestimation of the amount of 1-year-old activity and to make allowance for a greater abundance of strontium in other fissionable material it was assumed that the strontium-90 abundance would rarely exceed 5 per cent of the 1-year-old activity. The estimated annual amount of strontium-90 in Cincinnati precipitation for 1957 would then be no greater than 10 μμc/l, or one-eighth of the permissible level. Coagulation tests (*12*) have shown that it is relatively easy to remove suspended activity. It may, therefore, be postulated that rain-water treatment by alum-lime coagulation and filtration would reduce the annual strontium activity. If the ratio of strontium to total activity is the same for both suspended and dissolved activity it could be assumed that the strontium-90 in the treated water would be on the order of 4 μμc/l as compared to about 10 μμc/l if all of the strontium were soluble. Further studies, however, particularly of radionuclide analyses, are necessary to determine whether classification of mixed fission products has yet been accomplished.

For a comparison of composite semimonthly rainout collection at ground level and on the roof of the fourth floor of the SEC with the sum of individual rains (determined from the tray collector) eleven sets of data were available. Two of these sets of data covered periods of drought in which the composite samples in the collectors had only 46 per cent of the "dustout" detected in the tray collector. Presumably, radioactive dust is blown into and out of the collectors so that the more

frequent the sampling, the more radioactivity will be collected. The remaining data show:

1. The bucket sampler collected, on the average, a little more activity than the adjacent large tray collector.

2. The fourth floor roof bucket sampler collected from 50 to 103 per cent of the rainout found in the bucket sampler on the library roof, with an average of 82.5 per cent. Presumably, more rainout dust is captured by the sampler at ground level.

These studies indicate that semimonthly, or preferably weekly, composite bucket samplers, which for best results should be located several stories above ground to avoid aerosol contamination, should be satisfactory collectors where the fallout is largely in the form of rainout. In areas of low rainfall and potential dustout it would be advisable to keep distilled water in the bucket or to arrange to trap the dustout by other means.

Five-Year Fallout Summary

Studies of Cincinnati fallout have been continuous since March 1953 (*9, 13, 14*). The results, recapitulated in Fig. 4, show the annual deposition of

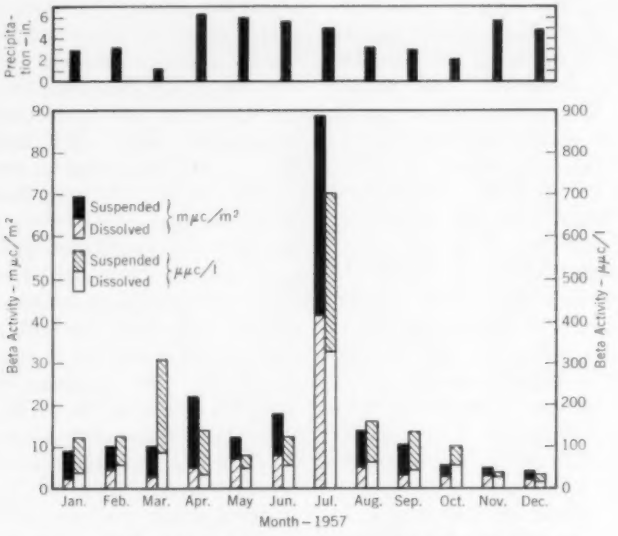

Fig. 3. Monthly Deposition of Long-Lived Fallout, 1957

Shown are 1-year-old bomb debris, in terms of millimicrocuries per square meter and, based on monthly precipitation, micromicrocuries per liter of rain water.

1-year-old bomb debris has increased each year from 31 mμc/sq m in 1953 to 210 mμc/sq m in 1957, an increase of 677 per cent. The total cumulative deposition for the 5-year period was 490 mμc/sq m and the total precipitation was 195 in. There was a concentration of 1-year-old activity of 98 μμc/l and an estimated strontium-90 concentration of about 5 μμc/l. Actually, the interaction of bomb debris

with soil and vegetation causes its removal from the rain by adsorption or exchange and possibly its translocation by physical (runoff) and biological mechanisms. If the strontium-90 in the Cincinnati rainout of 1953–57 were distributed to a depth of about 2 in. in soil having a density of 2.22 it would amount to only 0.1 $\mu\mu$c/g of soil.

Cistern Water Studies

Studies were made of cistern water to determine the maximum, minimum, and average beta activity, the range of the percentage of total activity associated with dissolved solids, and the estimated amount of 1-year-old activity. The latter estimate was based on the extrapolation of decay data. The results of these studies are shown in Table 2.

A minimum activity of 80 $\mu\mu$c/l was found in one November sample as compared to a maximum activity of 10,440 $\mu\mu$c/l in an August sample. The average monthly activity varied from 122 $\mu\mu$c/l in November to 2,530 in August with a yearly average of 629. The higher values generally correspond to young bomb debris with a high decay rate and, to some degree, cistern waters containing a high percentage of suspended (potentially settleable) activity. Compared to rain, the dissolved activity range percentage is generally higher, which indicates natural purification by subsidence in the cistern. Former findings (*9*) that cistern sludge contains an appreciable amount of the rainout corroborates this statement.

Of considerable interest is an estimation of 1-year-old activity of which 2.3 per cent (*11*) or more may be due to strontium-90. Table 2 shows that the 1-year-old activity varied from 10 to 129 $\mu\mu$c/l with an 11-month average of 67. It may be estimated that the average strontium-90 activity was at least 1.7$\mu\mu$c/l and possibly two to three times higher if allowance is made for errors of extrapolation and classification of radiounclides in air and water.

Surface Water Studies

The results of monthly grab samples from ten stream stations on the Big Miami, Little Miami, and Scioto rivers

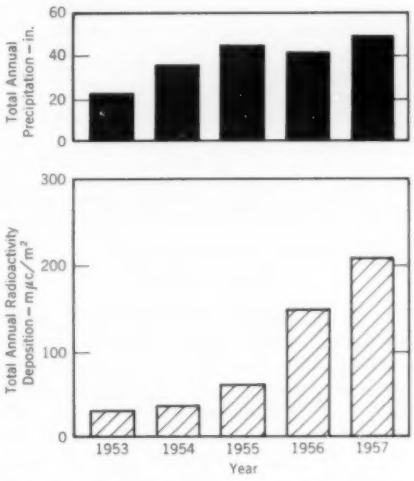

Fig. 4. Annual Deposition of Long-Lived Fallout, 1953–57

Total annual deposition of 1-year-old bomb debris (estimated) is here related to the total annual precipitation.

were available for a correlation of stream activity with Cincinnati rainout. Some of the stations are nearly 100 mi from Cincinnati so that the fallout at these stations could differ from that at Cincinnati.

The monthly average stream results, in Table 3, show a variation in total beta activity of 26–190 $\mu\mu$c/l with an annual average of 70. Stream activity in solution varied from 30 to 65 per

TABLE 2

Cistern Water Radioactivity, 1957

Month of Collection	Number of Samples	Gross Beta Activity* — $\mu\mu c/l$			Dissolved Activity Range %	1-Year-Old Activity, Average $\mu\mu c/l$
		Maximum	Minimum	Average		
February	5	469	184	293	34–67	70
March	2†	542	262	402	43–66	100
April	1			900	38	129
May	2	1,000	226	613	58–67	94
June	1			247	39	115
July	7	1,025	121	626	48–93	30
August	18	10,440	480	2,530	18–84	110
September	13	1,740	250	693	12–88	48
October	3	325	289	305	27–78	10
November	3	179	80	122	11–89	16
December	1			190		10
Average				629		67

* Total activity corrected for decay to date of collection.
† Excluding four samples from new cisterns having an unknown volume of purchased treated water and an activity of less than one-tenth average activity of the other cisterns.

TABLE 3

Comparison of Beta Activity of Surface Waters With Cincinnati Rainout, 1957

Month	Cincinnati Rainout* Total $\mu\mu c/l$	Beta Activity of Surface Waters†			Decontamination Factor§
		Total $\mu\mu c/l$	Dissolved %	Reduction‡ %	
January	555	44	41	92.1	13
February	432	36	48	91.8	12
March	1,265	48	42	96.2	26
April	1,290	54	54	95.8	24
May	520	84	40	83.8	6
June	1,790	117	30	93.5	15
July	33,200	190	50	99.4	170
August	2,120	80	50	96.0	27
September	4,310	76	39	98.2	57
October	1,090	26	65	97.6	41
November	191	49	47	74.3	4
December	496	36	62	92.7	14
12-Month average	3,938	70	47	98.2	

* Total activity as of the first of the month following deposition divided by monthly precipitation.
† The arithmetical average of monthly tests at four sampling stations on the Big Miami River from Venice, Ohio and upstream, one station on the Mad River, one station on the Little Miami at Newtown and four stations on the Scioto River below Columbus, Ohio.
‡ Reduction is determined:

$$\frac{\text{rainout} - (\text{stream activity} \times 100)}{\text{rainout}}$$

§ Decontamination is determined:

$$\frac{\text{rainout}}{\text{activity of surface waters}}$$

cent with an annual average of 47. The reduction in the activity of rainout is given as a percentage, varying from 74.3 to 99.4 per cent with an annual average of 98.2 per cent, and as a decontamination factor, which is plotted against rainout concentration in Fig. 5.

Summary

In 1957 the annual fallout (largely rainout) in the Cincinnati, Ohio, area amounted to 15,200 mμc/sq m of which 56 per cent was suspended matter. A large proportion of the fallout was young fission product (2–5 days old). The 1-year-old activity of this fallout was estimated to be 200 mμc/sq m. In 50 in. of total annual precipitation this amounts to an average concentration of 170 μμc/l.

Cincinnati cistern waters contained an average of 630 μμc/l of gross beta activity at the time of collection. The 1-year-old activity was estimated to be only 73 μμc/l, or about one-half of the rainout.

Stream water samples from three rivers in southwest Ohio contained an average of 70 μμc/l at the time of collection. About one-half of the activity was associated with suspended solids, which can readily be removed by conventional water treatment processes.

About 98 per cent of the annual rainout is not accounted for in stream samples. The implication is that the activity is adsorbed on vegetation and soil or otherwise removed by natural agencies. Because this occurs the environment is receiving radioactive contamination of a permanent and cumulative nature with respect to long-lived radionuclides. Studies on its distribution in food and animal feed are, therefore, of particular importance.

Fallout as rainout and snowout is a simple and reliable measurement of the degree of environmental contamination. The distribution of rain is so variable that the amount of fallout (which depends on both rain and the presence of radioactive clouds) must also be extremely variable. Furthermore, the relation of fallout to the stage of plant growth or harvesting could cause a variable contamination of produce and animal feed.

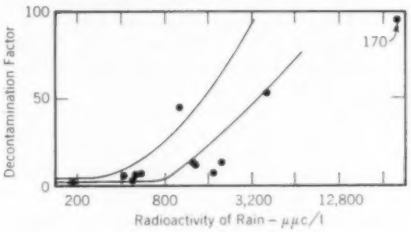

Fig. 5. Decontamination of Rain by Natural Agents

The decontamination factor is plotted against rainout concentration. The lines delineate the range of 1956 decontamination factors; the dots represent the 1957 monthly decontamination factors. The July rainout of 33,200 μμc/l (Table 3) resulted in a decontamination factor of 170, which corroborates the 1956 trend.

Acknowledgments

The six individuals who, in 1957, permitted tap water samples to be taken from their cistern supplies for testing were: Kenneth Shelly, Montgomery; Gerald Karches, College Hill, Cincinnati; Dade W. Moeller, Anderson Township; Charles M. Palmer, Amelia; Edwin E. Geldreich, Amelia; and William A. Moore, Newtown; all in Ohio.

The results of the monthly tests of grab samples from the Big Miami, Little Miami, and Scioto rivers were furnished by the Ohio Department of

Health, through F. Holman Waring, chief sanitary engineer.

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Colorado River Aqueduct as a Source of Present and Future Supplies in Southern California

Robert B. Diemer

A paper presented on Oct. 29, 1958, at the California Section Meeting, Los Angeles, Calif., by Robert B. Diemer, Gen. Mgr. & Chief Engr., Metropolitan Water Dist. of Southern California, Los Angeles, Calif.

IT is generally agreed that Southern California is approaching the day—less than 20 years ahead—when a new supply of water will have to be available to meet the needs of industry and the ever-growing population. The Metropolitan Water District of Southern California (MWD), together with many other organizations in Southern California, has stressed the necessity of pressing forward with the development of surplus water in the northern part of the state in addition to resources in the southern part.

One of the essentials of a statewide water development is a constitutional amendment that will insure to the areas of origin and the areas of deficiency a firm right to water that may be allocated to them for their use and require that the areas benefited by the development should bear their part of the cost. Thus far, all efforts on the part of Southern California to obtain a fair and workable constitutional amendment have been unsuccessful, even though this question has been before the state legislature at its last three sessions.

Past Projects

It is nothing new for Southern California to be looking for a new supply of water. More than 50 years ago Southern California began its change from a grazing and agricultural region to a horticultural area with large urban centers. It became increasingly evident that, in order to meet this change, water would have to be imported from distant sources. Los Angeles completed its Owens River Aqueduct, with an annual capacity of 320,000 acre-ft, in 1913. It was soon apparent that this supply would be inadequate to supply the long-range needs of the city.

In December 1928 the MWD was organized to bring water from the Colorado River to the coastal plain of Southern California, or a distance of more than 250 mi. In 1931 the voters of the thirteen cities comprising the MWD, by a vote of five to one, authorized a bond issue of $220,000,000 to cover the cost of building the aqueduct system to serve Southern California in its first development.

During the planning and building of the aqueduct in the early 30's, a vigorous opposition was expressed by some engineers and civic leaders to the plan of the MWD to build a full-size aqueduct to carry 1,600 cfs from the Colorado River to Southern California. As a result, it was decided to economize, building part of the aqueduct with a half capacity of 800 cfs and the pumping plants with three pumps of 200-cfs

capacity. It was decided to build 92 mi of tunnels, 63 mi of canals (Fig. 1), 55 mi of covered conduit and 7 mi of siphons to full capacity, as it had been determined that the half-capacity aqueduct sections cost 80–85 per cent of the full-capacity sections. Twenty-two miles of siphons were built with half capacity (800 cfs), and three pumps (each 200-cfs capacity) were installed

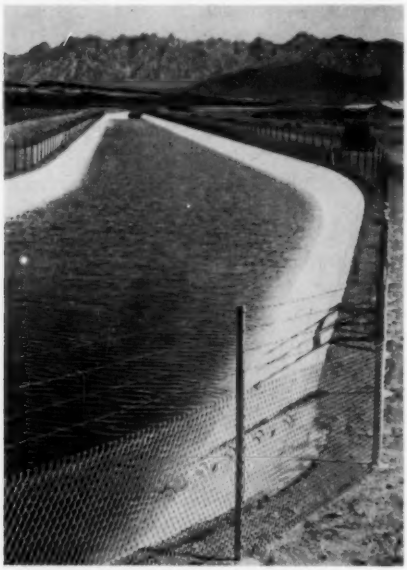

Fig. 1. Canal Section of Colorado River Aqueduct

These concrete-lined open canal sections make up 67 mi of the 621-mi system.

at the five pumping plants in order to pump the water 1,617 ft to an elevation about 1,800 ft above sea level at Hayfield. The initial pumping capacity restricted the total annual flow in the aqueduct to about 400,000 acre-ft.

Ground Water Depletion

Since the aqueduct was put into operation in 1941, 17 years have passed. At that time there were thirteen cities, including Los Angeles, in the MWD. The total area situated in Los Angeles and Orange counties was approximately 600 sq mi, the population 2,000,000, and the assessed valuation $1.9 billion. Adjacent areas were not concerned about a supplemental water supply; they were content to pump from the bountiful supply of water in the underground basins, which are Southern California's greatest water supply asset. The extended drought which prevailed during 1944–56, together with the amazing population growth, and the influx of industry in the southland, started mass annexations to the MWD in 1946. At that time, as at the present time, there were many in Southern California who looked ahead for additional water supplies, but, even though many areas joined the MWD, use of water from the underground basins continued. Overdraft, exceeding 300,000 acre-ft annually, has so depleted the underground basins in Orange, Riverside, San Bernardino, and Los Angeles counties that now there is a probable deficiency of more than 1,500,000 acre-ft in underground storage.

While the depletion of these basins was taking place, because the municipalities and private water companies were pumping from the basins instead of using water from the MWD system, the MWD pumps were working only part of the time. In 1941–47 only 178,000 acre-ft was delivered to Southern California. This was less than 10 per cent of the initial pumping capacity. In 1941–54, with the available pumping capacity it would have been possible to pump more than 5,000,000 acre-ft, but only about 1,400,000 acre-ft was delivered to Southern California. There would be no underground shortage in Southern California's coastal area if

the facilities of the MWD had been used instead of these underground basins.

Today there are 84 incorporated cities and a number of large, unincorporated areas in the MWD, comprising an area of more than 3,200 sq mi in Los Angeles, Orange, San Diego, Riverside, and San Bernardino counties. The population served by MWD is now 7,000,000 and the assessed value of MWD is more than $12 billion. Both the population and the assessed valuation represent about half of the entire state. During the past 4 years, MWD agencies have taken all the water that the facilities have been able to deliver.

New Construction Program

Since early in 1952, the MWD, in order to meet increased demands, has been engaged in a construction program that will bring the Colorado River Aqueduct to its full planned delivery capacity early in 1960. As previously stated, the aqueduct in its initial development was able to deliver water at the rate of 600 cfs, amounting to a firm total of about 400,000 acre-ft annually. The construction program now heading towards completion will increase the aqueduct's diversion from the Colorado River to 1,212,000 acre-ft annually, or more than 1 bgd.

The aqueduct construction program, initiated in 1952 and estimated at $200,000,000, falls into six general divisions:

1. The installation of six additional pumps in each of the five pumping plants will bring the number of pumps in each plant to a total of nine. Units 4 and 5, completed in 1957, increased the pumping capacity from 600 to 1,000 cfs, and the completion of the nine units will increase the installed capacity to 1,800 cfs. Installation of the additional pumps required the enlargement of the pumping plant building and the installation of two additional delivery lines from each pumping plant into the aqueduct.

2. Construction of an additional 22 mi of siphons on the aqueduct will increase the capacity from 800 to 1,800 cfs (Fig. 2, 3).

3. Construction of more than 100 mi of pipeline and tunnels varying from 36 to 120 in. in diameter will expand the aqueduct's distribution facilities for delivery of water to the member agencies.

4. Construction of the Garvey Reservoir will give an additional storage capacity of 1,500 acre-ft to the distribution system.

5. The enlargement of Lake Mathews, the terminal reservoir on the aqueduct, will increase its storage capacity from 107,000 to 182,000 acre-ft.

6. Additional filtering facilities are to be constructed at the Frank E. Weymouth Softening and Filtration Plant, near La Verne.

This construction program will bring the aqueduct to its full capacity early in 1960 and will enable local water agencies within the boundaries of the MWD to carry forward a major program of underground water basin replenishment. This will also permit the use of additional quantities of Colorado River water for other purposes.

Financing of Construction

The first development of the aqueduct system, completed in 1941, required the sale of bonds in the amount of $180,000,000 from the $220,000,000 issue voted in 1931. The last of the bonds from this issue were recently sold to help finance the $200,000,000 expansion program initiated in 1952. Interest and amortization payments on these bonds have been provided very

largely by tax money paid into the MWD treasury by cities and other political subdivisions in its service area. Several of the member cities have paid, or are paying, most of their annual assessments from funds derived from municipal water sales.

In addition to the money collected from taxes and other assessments, an increasing amount of revenue is being derived each year from the sale of water to MWD's constituent areas.

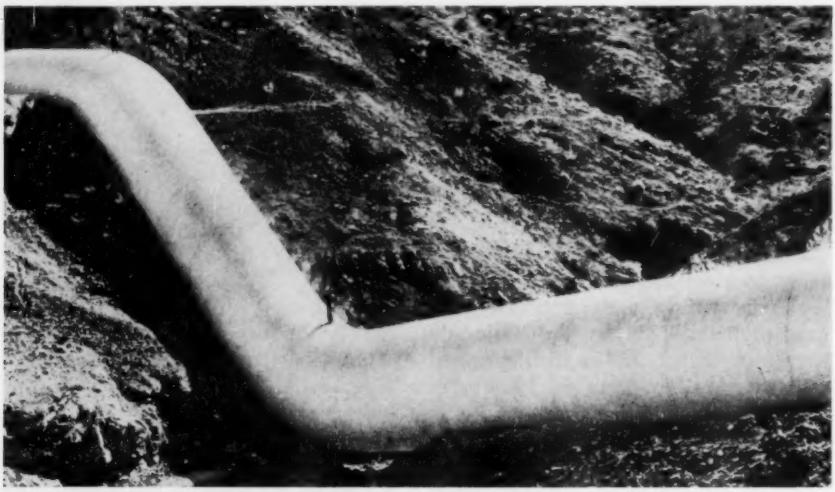

Fig. 2. Inverted-Siphon Section of Aqueduct From the Colorado River

This part of the MWD aqueduct traverses rugged mountain country about 2 mi west of the intake on Lake Havasu. This reinforced-concrete pipe is 16 ft in diameter. In all, the aqueduct system has 29 mi of inverted siphons.

In addition to the funds available from the 1931 bond issue and from water sales, funds are derived from new areas annexed to the MWD since its organization in 1928. Areas permitted to join the MWD obtain the same right to enjoy water service as the original members. This right is earned by the payment of back taxes, which represent the total of annual tax payments that the area would have made if it had been one of the original members, plus simple interest at 4 per cent from the due date of each payment to the date of annexation. If the annexing area does not desire to pay this back-tax charge in cash, this charge, amortized at 4 per cent interest over a 30-year period, can be paid in 30 annual payments. The total of these charges to date is $188,000,000, of which $153,000,000 remains to be paid during the next 30 years.

In March 1956 the state legislature amended the Metropolitan Water District Act to enable the board of directors of MWD to issue short-term bonds to be paid off with funds received from annexation fees. These short-term bonds are to be retired in not more than 12 years, and the amount of those bonds outstanding at any time is limited to

50 per cent of the annexation charges receivable. No increase in taxes is necessary to pay off the short-term bonds.

Overwhelming approval of Proposition W by voters in the area served by MWD was given in 1956. Under the provisions of Proposition W, the MWD is authorized to issue short-term bonds to help finance the expansion program. A total of 1,408,232 votes was cast on Proposition W, or 92 per cent of the total vote cast. This forcefully shows that the people of Southern California are alert to the critical water situation. To date, short-term bonds in the amount of $51,000,000 have been sold, and it is anticipated that about $30,000,000 of additional bonds will be sold to finance the current expansion program.

Restoration of Ground Storage

All costs of the MWD aqueduct system are being paid for by those who live within the district. There is no federal subsidy of any kind. This is a Southern California project, owned, controlled, and paid for by the people it serves.

Southern California has been slow to realize that something should be done to save the underground basins. The importance of these basins on the coastal plain of Southern California was recognized fully by Frank E. Weymouth, the first general manager and chief engineer of the MWD (*1*):

> Not many years ago, bountiful supplies of ground water were available almost everywhere at reasonable depths. Over an area of 315 sq mi water flowed from wells under artesian pressure. Artesian flow has now practically disappeared, and water levels have dropped everywhere. Levels along the coast have been pumped down below sea level, causing salt water to flow landward, and wells in the foothill regions have been lowered to bedrock. There is evidently less water in the ground now than there was a few years ago, and levels are dropping more rapidly than ever before.

To whatever extent overdraft is due to a temporary condition of drought, it is permissible. These underground basins are one of the principal assets of Southern California, and it is entirely proper that they should be used to equalize the fluctuating water supply. But they are now being drawn down too deeply. Supported by an inflow which will keep them sufficiently well filled in normal times, these underground reservoirs are valuable insurance against temporary failure of other sources; empty, they are a detriment to proper utilization of normal local supplies.

Fig. 3. Laying of Pipe Sections in the Big Morongo Siphon

This huge machine is moving a pipe section into place. The sections in the background are waiting to be moved ahead.

A quarter of a century passed before the cities and agencies in control of the depleted underground basins could be aroused to do very much in the way of restoring them. There was sufficient capacity in the aqueduct as initi-

ally constructed to have prevented this depletion; however, until recently the local agencies within the boundaries of the MWD did not chooose to cut down their heavy drafts upon the underground basins; nor did they choose to purchase large, additional supplies of Colorado River water to help restore the basins.

The Orange County Water District started the purchase of Colorado River water for spreading in 1949, and since that year it has spread 450,000 acre-ft. From replenishment assessments and annual ad valorem taxes, Orange County plans to purchase about 85,000 acre-ft annually for spreading. It has been estimated that 375,000 acre-ft will be required to refill the Santa Ana Basin in Orange County.

TABLE 1

Estimated Diversions for the MWD from the Colorado River

Year*	Diversion *acre-ft*
1958–59	600,000
1960–61	715,000
1965–66	885,000
1970–71	1,055,000
1975–76	1,212,000

* Five-year intervals after 1961.

Since 1954, the Los Angeles County Flood Control District has purchased about 265,000 acre-ft for spreading in the Central and West basins. Funds to purchase water were obtained from a tax levy of 5 cents per $100 valuation in Zone 1, which lies south of Whittier Narrows in the San Gabriel Valley, and Zone 2 in West Basin.

The MWD has tentatively approved plans for the construction of several feeder lines, costing about $19,000,000, to deliver natural Colorado River water into Central and West basin districts for spreading and injection to prevent sea water intrusion after these districts have formed a replenishment district, and an order has been placed for approximately 200,000 acre-ft of water annually. This water will be used for spreading in the San Gabriel Basin south of Whittier Narrows and for injection underground along the coast from Manhattan Beach to Seal Beach. These replenishment measures will do little more than meet the overdraft. It has been estimated that the underground storage in the Central and West basins can be increased 800,000 to 1,000,000 acre-ft by spreading and injecting.

Future Prospects

With the completion of its facilities in 1960, the MWD will be able to deliver into Southern California about 1,200,000 acre-ft annually. Estimates indicate this to be sufficient to supply the MWD's needs until 1975. There are many who claim that water from northern sources will be required in Southern California by 1970, or even earlier. Demands on the MWD system do not justify this prediction, however. During the past 12 months, when the rainfall at Los Angeles from October 1957 to October 1958 was 18.0 in., as compared to 7.40 in. for the previous year, the water demand, not including spreading, was 360,000 acre-ft, as compared to 410,000 acre-ft for the same period in the preceding year. During this time, the aqueduct's terminal reservoir, Lake Mathews, filled to capacity; the Orange County Water District and the Los Angeles County Flood Control District, because of floods, suspended spreading operations in the Santa Ana and San Gabriel basins; the water demands throughout the MWD fell off, and

it was necessary to reduce aqueduct pumping operations from a four-pump flow to a two-pump flow for more than 3 weeks. One pump was necessary to keep the San Diego aqueduct flowing to its capacity of 200 cfs. During this period, the city of San Diego saved approximately 100,000 acre-ft of flood water in its surface reservoirs. From July to October the flow in the San Diego aqueduct had been reduced from 200 to 145 cfs, as the terminal reservoir, San Vicente, was almost full to its capacity of 90,230 acre-ft. This is an indication of what is to come in Southern California when the cycle of greater-than-normal rainfall again visits these areas; it will result in plenty of water in the Colorado River along with reduced water demands in the south.

With regard to future demands, the MWD each year receives from each of its member agencies an estimate of water requirements for the coming 3 years. These estimates have usually been found to be very optimistic, and the amount of water used does not nearly reach the estimated demands. As an illustration, for the period 1957–58 the estimated requirement was 657,000 acre-ft and the amount used was 560,000 acre-ft.

It should be noted that the full capacity of the aqueduct will not be required for day-by-day use for several years after 1958–59. Actually, 5,000,000 acre-ft of additional water available for diversion from the Colorado River will not be brought to Southern California during 1958–75 unless immediate steps are taken to replenish underground basins, which have been depleted to the extent of 1,500,000–2,500,000 acre-ft. The MWD aqueduct will be able to supply this extra amount of water above the estimated demands in the next 10 years. What is being done about it?

Need for Ground Storage

Up to the present time, the spreading of water in Orange and Los Angeles counties has resulted in little, if any, net recharging of the basins, as the basins have served as economical distributing systems leading to the numerous pumps for delivery of water to the users in the area. In the West and Central basins plans are being prepared for the formation of a replenishment district. When all the injection works are installed on the West Coast, Dominguez, and Alamitos barriers, the flood control district will require about 250,000 acre-ft of water annually. This, together with the estimated demands of about 100,000 acre-ft required for meeting the overdraft and replenishment of the Santa Ana Basin, will bring the demand from the Colorado River Aqueduct up to only 350,000 acre-ft annually for replenishment purposes. This is not enough to utilize the entire unused capacity of the aqueduct within the next 10 years. The various agencies in Southern California interested in water problems should concentrate on this situation. After 1960, there will be excess capacity in the aqueduct, and there is a place to store the water. While considering importation of surplus waters from the north, the MWD could insure a safe water supply to the coastal area of Southern California for many years by getting busy and filling the underground basins as soon as possible. If negotiations for bringing water from northern California result in delay and the supply from the Colorado River is exhausted sometime after 1975, then Southern California will be able to draw down its basins

again just as it has been doing for the past 25 years. This is not a sound policy if long continued, but in an emergency the refilled ground water basins could assist in meeting water needs for several years after 1975.

It is hoped that this drawdown of the basins will not be necessary. Efforts should be continued to get water from northern California, provided that a satisfactory constitutional amendment can be obtained to guarantee a firm water right to both the areas of deficiency and the areas of origin.

Other Possible Sources

Another source of water supply that should be considered in the future, after water from the north has been utilized, is reclamation of sewage outflow to the ocean. At present this waste amounts to approximately 500,000 acre-ft annually. When the full allotment from the Colorado River is put to use in Southern California, the outflow may reach 650,000 acre-ft annually. Because this sewage effluent contains industrial wastes and detergents, its reclamation will be expensive.

Still another source of supply may be from the Pacific Ocean. Investigations of methods for conversion of sea water are being made by governmental and private agencies, but no definite information is available at this time as to the costs. It is well established, however, that conversion of sea water will cost much more than water from the north. The costs that have been quoted, $200–$400 per acre-ft, are for water produced at sea level, and do not include the costs of pumping and distribution to higher levels. Southern California cannot safely await the developments of reclamation of sewage outflow or conversion of sea water; it should concentrate its efforts to bring water from northern California.

Conclusion

The solution to California's water problems, to a degree, depends on four major factors.

1. A fair plan of allocating available water resources to areas in need of additional water
2. A constitutional amendment that will guarantee to the areas of origin and the areas of deficiency a permanent right to water allocated to these areas
3. A program of financing that will take into account the ability to pay for benefits received
4. Engineering plans that will provide the safest and most economical route and design for all water delivery lines and storage works.

California's water industry is coming to understand that its problems can only be solved by the united effort of the people throughout the state. To some, this may appear to be impossible, but, as one looks back over the years of fine accomplishment, one cannot help but feel assured that the roadblocks now ahead will also be cleared away.

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Future Needs and Supplies at Los Angeles

Burton S. Grant

A paper presented on Oct. 29, 1958, at the California Section Meeting, Los Angeles, Calif., by Burton S. Grant, Gen. Mgr. & Chief Engr., Dept. of Water & Power, Los Angeles, Calif.

FOR more than 50 years the city of Los Angeles has met a continuing challenge to provide an adequate water supply in time to supply its future growth. The city has attained its present population of 2,400,000 people (one-sixth of the population of the entire state of California) because there were men of vision and courage in charge of water planning who were able to convince the citizens, when the population was only 250,000, that water would have to be imported from distant sources to permit the community to grow.

The rapid growth in the past 50 years, which undoubtedly surpasses anything that was thought possible by those early pioneers in long-range water planning, has created continuing problems to the present day. The record of Los Angeles water consumption in the recent past illustrates the continuing challenge to its water planners who must meet the demands when they occur. The amount of water used for domestic, commercial, and industrial purposes in the city has increased 40 per cent in the last 10 years.

Present Supplies

Water is now obtained from three different sources to meet the growing demand. In 1948 the city's water needs were served 75 per cent from its Owens River Aqueduct, 22 per cent from the Los Angeles River and local wells, and 3 per cent from the Colorado River Aqueduct. In 1958 these percentages were approximately 70, 22, and 8 per cent, respectively. It is estimated that in 1980 they will be about 47, 13, and 40 per cent, respectively.

Since 1941 the Los Angeles water department has not been required to import added sources of water on its own; through its membership in the Metropolitan Water District of Southern California it has assured itself of enough water to provide for its growth for several years in the future.

The sixteen existing connections with the aqueduct can provide, at the present time, a momentary capacity of 192 cfs of Colorado River water.

Capital Additions

Notwithstanding the availability of Colorado River water, a very large program of capital additions in the transmission, regulation, and distribution branches has been necessary to fulfill the 40 per cent increase in use in the past decade. It is expected that a heavy program of system expansion will be required for several years in the future to provide for continued growth.

Since 1948 capital additions have totalled $164,170,000. The number of

miles of water mains in the system has increased from 4,519 to 6,001. Service connections have increased from 365,324 to 552,305.

Transmission mains 36 in. in diameter and larger—11.5 mi of them—have been completed to bring Colorado River water into the system.

An additional 54 mi of transmission mains has been installed to give service to growing areas of Los Angeles where water use outgrew the transmission facilities built many years ago or where there were no facilities before.

TABLE 1

Water Revenue Bonds for Los Angeles, 1949–58

Date	Amount *millions of dollars*	Effective Interest *per cent*
Nov. 15, 1949	20	2.33
May 15, 1951	10	2.14
Mar. 25, 1952	5	2.11
Jan. 13, 1953	5	2.75
Jun. 9, 1953	5	3.07
Jan. 6, 1954	9	2.46
May 11, 1955	6	2.28
May 2, 1956	9	2.94
Feb. 20, 1957	9	3.13
Jan. 29, 1958	9	3.06
Total	87	

Twenty-one new reservoirs and tanks were constructed and 24 new pumping plants were installed.

At this date the Los Angeles system has a peaking capacity well over 2,500 cfs. On Sep. 1, 1955, a peak demand of 2,067 cfs was delivered.

For the next 5 years it is estimated that $85,000,000 will be spent on continued system expansion. Major transmission lines within the city, which are essential to tie in the various sources of water supply and to move the needed large volumes of water to all parts of the city to serve the demands, will be continued. San Fernando Valley, the area where the most rapid growth has been experienced in recent years, is expected to continue its phenomenal development. The new Granada Trunk Line skirting the northern and western edges of this vast valley will be completed. This line was started in 1954 and permits the development of 13,000 acres in the city at elevations of 1,000–1,200 ft above sea level.

An added 5,100 acre-ft of new regulating storage will be completed and present reservoir facilities will be increased approximately 7,040 acre-ft in capacity.

An experienced staff of engineers is hard at work planning the most economical way to make necessary additions to the distribution, pumping, and storage works to deliver water where and when needed. Planning the layout of these additions, performing the field surveys and explorations required, drawing the plans and specifications for actual construction, and inspection of the construction are a major project when it is realized that in each decade a water supply is furnished for 500,000 new residents. This is equivalent to a city the size of Milwaukee, Denver, or Seattle.

Much of the new development is now in hill areas requiring pumping plants and tanks. A pumped water system at 2,450 ft above sea level was recently placed in service to increase the range of water service in Los Angeles, which now extends from sea level to this new high.

Financing

In 1947 the citizens of Los Angeles authorized by a large majority the issu-

ance of revenue bonds for the financing of the department's expansion program.

Since then water revenue bonds have been issued as shown in Table 1.

Originally the value of revenue bonds that could be issued was limited to the amount of earned surplus (not including surplus arising from contributions in aid of construction) derived from the operation of the works. Later the voters approved a change to include donations in aid of construction as surplus. Still later, the electorate approved a change in the ratio of bonds that could be issued to the surplus so that at the present time the surplus need be only 80 per cent of the total of all bonds outstanding.

Under the new policy of revenue bond financing the present generation of water users is relieved of paying in cash for all work needed now to be able to serve future generations. Future generations will help pay for those parts of the system that will benefit them when they are using the system.

Future Sources

The water department has been active in discussions on sewage reclamation, conversion of sea water, and the Feather River plan, which are being analyzed and considered for future sources of water.

The department's engineering staff, with its vast experience in estimating future water demands, has made an analysis of future needs and has reached the conclusion that Southern California will need additional supplies of water by about 1974, if Southern California's rights in the Colorado River are confirmed by the courts.

Reuse of waste water offers possibilities for the future, but even if it were economical it would never be sufficient to meet all future needs.

Conversion of sea water appears to be out of the question because of cost, not to mention the added cost of pumping up from sea level to make it useful.

Cooperation is being extended to the state director of water resources, legislative committees, and associations that are studying the Feather River plan, in the interest of early consummation in the most economical manner. Members of the department's staff are lending their support in many ways in the engineering, financial, and legislative phases.

The water department is in the position of trusteeship to the people of Los Angeles; the people will look to it for guidance in supporting the most logical and economical planning of California's water resources so as to provide the greatest good to Southern California as well as the rest of the state.

Increasing Water Yield in Southern California Mountains

James H. Patric

A paper presented on Oct. 31, 1958, at the California Section Meeting, Los Angeles, by James H. Patric, Research Forester, San Dimas Experimental Forest, Glendora, Calif., a branch of the California Forest and Range Experiment Station, Berkeley, Calif.

WATER scarcity is an old problem in Southern California. Southern California is considered to include the counties of: San Luis Obispo, Santa Barbara, Orange, Los Angeles, Ventura, San Bernardino, San Diego, and Riverside.) The early settler's needs were met from springs and streams and later from wells. As demand increased water tables correspondingly were reduced, sometimes to a point which permitted sea water intrusion. In 1900, local sources supplied the 321,000 people of the region, but by 1913 water was being imported from outside sources. At present (October 1958) strenuous efforts are being made to pipe Feather River water into the area, which now has a population of nearly 8,000,000. To state the problem briefly, an ever-increasing majority of California's people live in a semiarid area where local water supplies are inadequate.

One reason that this increasing scarcity of water is so important to the people of Southern California is the difference in cost between local ground water and water from other sources. Table 1 gives some water costs in Los Angeles County as an example of this. These figures are good reason why about two-thirds of the water used in Southern California is from local sources so that these sources are being dangerously overdrawn. The entire population would benefit if local sources could better satisfy the demand for clear, safe water.

Mountains as Water Source

The civic and public leaders of Southern California have known for a long time that precipitation is the source of all fresh water and that most of the region's rain and snow falls on the high coastal mountains. In fact, these mountains are the only place in the region where rainfall usually exceeds natural consumption of water. The mountain watersheds are, therefore, the source of most of the valley well water and probably are a key to the problem of increasing safe ground water yields.

The mountains also represent an ever-present threat of floods. They are, geologically, young mountains, steep and unstable with shallow, rocky soils. Most of the rainfall occurs during winter months, often as high-intensity storms, and as soon as soils are wetted rainfall can concentrate quickly into flood flows. Floods and erosion from burned watersheds have been particularly devastating. So acute is the problem that Los Angeles County has spent about the same amount of money

on flood control as it has on alleviating the perennial water shortage.

San Dimas Forest

The California Forest and Range Experiment Station, Berkeley, is maintained by the Forest Service of the US Department of Agriculture, in cooperation with the University of California, Berkeley. In 1933 the San Dimas Experimental Forest (*1*) was established at Glendora, Calif., as a branch of the Experiment Station. Research at the forest, which was set up as a field laboratory to study watersheds and their management, is conducted with cooperative assistance from the California Department of Natural Resources, Division of Forestry.

TABLE 1

*Approximate Water Costs, Los Angeles County—1957**

Source of Water	Cost $/acre-ft
Local ground water	12–18
Owens Valley, Calif.	20
Feather River, Calif.†	45–60
Colorado River, N.M.	55–65
Distilled sea water†	150–250

* Source: California Department of Water Resources, Glendale, Calif.
† Estimated.

The San Dimas Experimental Forest is 17,000 acres in extent and lies about 35 mi northeast of Los Angeles. Several features make this forest ideal for its purpose:

1. The forest area is typical of the region's chaparral-covered mountains.
2. Deep canyons separate the forest from the main San Gabriel range and minimize movement of underground water into experimental watersheds.
3. The forest's major drainages contain many smaller watersheds suitable for study.
4. The forest has several kinds and ages of chaparral cover.
5. Two dams, built by the Los Angeles County Flood Control District, provide a means of measuring most of the stream flow and sediments produced by the forest.

Effect of Vegetation Cover

One of the first projects at the San Dimas Experimental Forest was to learn how brush-covered watersheds function. Among the questions studied were: how rainfall can be accurately measured in the mountains, how much rainfall is lost through evapotranspiration, and how much water is yielded for farm, city, and industrial use. Studies of climate, hydrology, and soil-plant relationships have provided some of the answers. Since 1934 detailed records have been kept of rainfall and stream flow from seventeen watersheds within the forest (Fig. 1). These watersheds are considered "calibrated"—that is, in a given storm the stream flow from one of these watersheds may be predicted accurately from the stream flow record of another.

Other studies have shown that vegetation on mountain watersheds consumes much of the rainfall, thus reducing its benefit to the population of the valley below. A study of the disposition of precipitation for the period 1938–53 was made in Monroe Canyon. During this period the average annual precipitation was 27 in. The study showed that an average of 15 in. of this precipitation was lost (3 in. intercepted by foliage, 12 in. lost due to evapotranspiration) and an average of only 12. in was available for use (3 in. stream flow, 9 in. ground water).

The best hope of increasing water yields lies, it is believed, in altering the existing soil-plant relationships.

Fig. 1. Stream Gaging Station

Stream gaging stations measure surface flows at the San Dimas Experimental Forest.

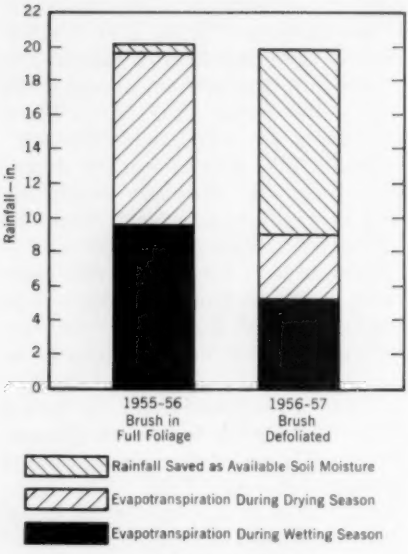

Fig. 2. Effect of Defoliaion on Evapotranspiration

In 1956–57 the brush was defoliated by spraying. Electric soil moisture–measuring instruments (reference 2) were used to determine soil moisture use.

Watersheds are composed of vegetation, soil, and the underlying rock. The vegetation consumes in its life processes much potentially useful water. Fortunately, vegetation is the component most easily managed and there are research data to show that alteration of a plant cover offers a promising means of increasing the yield of useful water.

Different plants in the plant cover vary in the amount of water they consume. A series of 26 reinforced-concrete lysimeters was built in 1935 at the experimental forest in order to study water use by plants. The lysimeters are tanks 10 ft wide, 21 ft long, and 6 ft deep, each filled with 65 tons of thoroughly mixed local soil. Environmental conditions are identical for each tank; the plant species grown in the lysimeters are the only variables in these long-term experiments. Runoff and seepage water yields are measured in underground collecting tanks. Surface losses of soil moisture due to direct evaporation and to plant transpiration are measured by electric instruments (*2*). After 6 years of testing the lysimeters with uniform grass covers, no significant differences were found in their responses to rainfall.

A long-term experiment was begun in 1946 to determine what happens to rain falling on: [1] bare soil, [2] native bunch grasses, [3] soil with Coulter pine, and [4] soil with several shrubs dominant in the local mountains. Results to date (October 1958) include data from a period of drought years. The most runoff naturally came from bare soils. Infiltration of rainfall into plant-covered lysimeter soil was more than twice as great as into bare soil. Water absorbed into the soil was com-

pletely used by all woody plants, but even in the drought years seepage yields were produced from grass-covered lysimeters. Table 2 gives some of the results of this experiment for the drought period Oct. 1, 1952–Sep. 30, 1956.

These experiments have led to two conclusions. First, although bare soils produce a lot of water, this water often comes from the watersheds laden with debris and as wasteful, damaging floods. Second, of the vegetation tested in the San Dimas lysimeters, grass is apparently the best watershed cover to increase the ground water yield. Soil moisture not consumed by grass can percolate down to the ground water table.

TABLE 2

Disposition of Average Annual Rainfall, San Dimas Lysimeters, Oct. 1, 1952–Sep. 30, 1956*

Vegetation	Rainfall Depth—*in.*			
	Surface Runoff	Infiltration	Seepage	Loss†
None	13.0	7.7	0	7.1
Pine	5.6	15.1	0	15.1
Chamise	4.1	16.6	0	16.5
Grass	4.0	16.7	1.7	15.3
Buckwheat	3.5	17.2	0	17.2
Scrub oak	3.3	17.4	0	17.5

* Average was 20.7 in., with a range from 16.01 to 25.39 in.
† Loss is determined:

$$L = R - (r + s \pm S)$$

where: L is loss, R is rainfall, r is runoff, s is seepage, and S is soil moisture storage. S is added if soil moisture storage increases during the period and subtracted if it decreases.

Field Studies

Further studies were made to determine if the water use patterns of vegetation grown in the lysimeters could be duplicated under more natural conditions. Tests were made in nine field plots, with covers of grass, grass and weeds, and mature scrub oak.

Figure 2 shows how evapotranspiration was affected by defoliation of an oak brush cover by spraying. The slopes of the field plots in which these tests were made averaged 30 per cent but no significant amount of runoff occurred. Soil depth averaged 12 ft, which is far above the average for the area of the tests (San Gabriel Mountains).

During the 1953–57 period the oak brush covers practically consumed all of the available soil moisture on their plots. So great was water use by oak brush that rainfall did not once soak these soils and no water reached the ground water table. In 1956 the brush on one set of plots was killed with hormone sprays. Water losses in the 12 ft of soil under the dead brush were less than half those under live brush.

A similar situation occurred on the adjacent grass plots (Fig. 3). Even though precipitation was below normal

from 1952 to 1956, it usually was sufficient to soak the grass-covered soils and percolate some free water to the underlying rock. This was true as long as a pure grass cover was maintained. In 1955 a dense weed growth invaded the grass plots. The combination of grass and weeds consumed almost as much water as brush did. In 1956 the weeds were killed with hormone sprays, leaving pure grass. During succeeding years soil moisture consumption on these plots returned to previous low levels and moisture was abundant at depths below 3 ft (Fig. 4).

Several conclusions were drawn from these tests:

1. The natural brush cover uses water extravagantly; therefore, killing the brush will save much soil moisture.

2. Converting brush watersheds to grass will save water only as long as the area is kept clear of invading weeds and brush.

3. Converting to grass will not save water on shallow soils. Evaporation and transpiration will use most or all of the available moisture in soils less than 3 ft deep.

4. Converting to grass will not save water on deep soils if rainfall is insufficient to replace soil moisture lost by evapotranspiration during the preceding year.

Fig. 3. Soil Moisture Runoff Plot

Plots of this type were converted from brush to grass in order to study the changes in water consumption and water yield which took place.

Application of Data

Using these facts as a guide the San Dimas Experimental Forest staff is placing whole watersheds under intensive management. The objective is to increase the yield of usable water without adding to the flood and erosion hazard. The staff has begun single treatments on two pairs of watersheds on the San Gabriel front. One of each pair will remain as an untreated control. As these are calibrated watersheds, it can be predicted, from records of untreated canyons, what the stream flow of the managed canyons would have been without treatment. The difference between the actual and the predicted stream flow will be a measure of the effects of management.

It was decided that rapid replacement of the native canyon bottom trees, which used large amounts of water, would be attempted in 870-acre Monroe Canyon. In February 1958 a start was made toward removing all trees growing on deep canyon bottom soils. So far 15 of a planned 80 acres have been cleared. Some native grasses are invading the cutover area, but seeding probably will be necessary on steep soils and on areas which have deep leaf litter. Adjacent 740-acre Volfe Canyon is being maintained as a control watershed. Preliminary data indicate a small but significant increase in stream flow from Monroe Canyon during the summer of 1958.

A slower process of replacement of brush with grasses is being attempted on side slopes of a calibrated Bell Canyon watershed. Here concrete structures measure stream flow and debris production from the steep, unstable mountain sides. A soil survey showed that 41 of the 100 acres in the managed watershed had soils more than 2 ft deep. In April 1958 a helicoptor was used to spray the brush on these deep soils with a hormone mixture. This resulted in a good leaf kill, but most of the woody parts of the brush are alive and little grass has invaded the area. It is expected that it will take at least two more annual sprays to kill the brush and permit grass to invade the area. An adjacent 62-acre canyon remains untreated as the control watershed. So far there are no data to show differences in actual and predicted stream flows from this watershed.

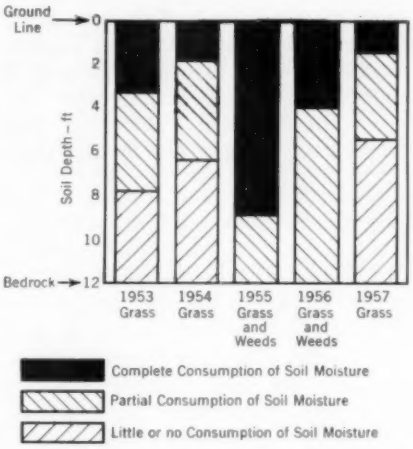

Fig. 4. Effect of Weeds on Soil Moisture

Weeds invaded the plot in 1955 and were killed in June 1956. Winter rains were adequate to bring the entire depth of soil to field capacity in every year except 1956.

Conclusion

These are pioneer studies and their progress is being followed with keen interest in many quarters. Flood con-

trol personnel are concerned with the effects of management on floods and debris production from watersheds. Scientists are interested in new techniques being used to measure soil moisture and consumption of water by plants. Sportsmen want to know how these operations will affect the hunting and fishing in canyons managed primarily to produce water. In a few more years it may be possible to answer some of these—and other—questions.

The work at the San Dimas Experimental Forest is just the beginning of applied watershed management research in Southern California. The cooperation being given by the California Division of Forestry, by Los Angeles County, and by other groups has enabled the staff to broaden its research program. If, through these studies, it can be learned how to increase water yields at a reasonable cost, it will be a long step toward easing the water shortage in Southern California.

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Water Losses in the Sierra Nevada

Allan J. West and Kenneth R. Knoerr

A paper presented on Oct. 31, 1958, at the California Section Meeting, Los Angeles, Calif., by Allan J. West and Kenneth R. Knoerr, Research Foresters, Forest Service, US Dept. of Agriculture, Berkeley, Calif.

CALIFORNIA'S snow zone occupies about 12,000,000 acres of timberland, brushland, and open and alpine lands and lies at elevations above 5,000 ft in the southern Sierra and 3,500 ft in the northern Sierra and Cascade ranges. About 9,000,000 acres of the zone are classed as commercial forest; this 9 per cent of the state's land area alone produces more than a third of the state's runoff (*1*). Most of the timber in the snow zone is as yet uncut, but forest managers are looking toward this high-elevation commercial forest, and it is only a matter of time until these stands are harvested (Fig. 1).

Current Research

How should the snowpack forests be managed to provide California with the quantity and quality of water it needs, when it most needs it? To answer this question, the California Forest and Range Experiment Station of the US Forest Service and the California Department of Water Resources joined forces in 1956 in an intensive program of snow management research (*2, 3*). This research venture is setting out to determine: how the timber can be cut and other snow zone lands managed to produce the greatest yields of water; what cutting patterns will retard melting and delay water delivery until later in the spring; and what effects various management alternatives will have on flood peaks and on sedimentation. Watershed foresters will have reached a major milestone when they learn how to manage forests to increase the total yield of water, to control its delivery, and maintain good quality.

The State Department of Water Resources, by matching federal funds, has helped to establish a $125,000-a-year research program. Eleven technicians—foresters, soil experts, and meteorologists—and a supplemental staff of field and clerical assistants are concentrating their efforts in six areas of California (Fig. 2). There are four main types of studies:

1. Inventories are being made to determine the location of the major water- and sediment-yielding areas in the Sierra snow zone and what proportion is forest, brush, grass, or bare ground. These reconnaissance studies, using aerial photographs, are being carried out in the Berkeley headquarters of the California Forest and Range Experiment Station.

2. The second group of studies involves meteorology, forest hydrology, and snow physics—studies necessary to develop ways of improving water yield. Some of the important questions are how snow accumulates and melts under

various forest conditions, how the wind blows when it is snowing, how solar radiation affects melting, and how much water is lost through interception, evaporation, and transpiration. A team of investigators at the Central Sierra Snow Laboratory near Donner Summit is collecting basic data on these questions.

3. The third group of studies is being made to determine which conservation methods are most effective for the various slopes and forest types of the Sierra. Studies of this nature are in progress at Swain Mountain in the headwaters of the Feather River, at Onion Creek in the headwaters of the American River, and at Sagehen Creek, part of the Truckee River Basin. At Sagehen the experimenters are assisted by the staff of the University of California's Department of Zoology in evaluating the effects of watershed management on fish habitat.

4. Fourth are the pilot studies to determine what happens when the lessons learned from basic studies are applied to entire watersheds. In preparation for this the streamflow performance of ten small watersheds is being evaluated. Five of these are at Onion Creek, in the headwaters of the American River, and the other five are in an experimental forest on Teakettle Creek in the upper Kings River Basin. These streams will be calibrated until the flow of any one of them can be predicted from the records of another. When this is done, one will be maintained as a control. To the others, different forest-cutting and management practices will be applied—some aimed at maximum water production, others at maximum delay in water delivery. These practices will be evaluated in terms of yield and delivery.

Fig. 1. California's Snowpack Reservoir

More than half of California's water supply comes from the snow zone of the Sierra Nevada and Cascade Mountains.

Two studies of evapotranspiration losses will illustrate the basic research

now underway at the Central Sierra Snow Laboratory. Evapotranspiration losses include evaporation from the soil and snow surface, from the rain and snow intercepted by vegetation, and transpiration from the leaves of trees or other vegetation. These water losses are important because any water returned to the atmosphere is lost to stream flow. One of the evapotranspiration studies being conducted is an investigation of summer losses; another is being made on winter losses.

Summer Losses

Summer evapotranspiration covers the period from the end of the snow melt in the spring to the beginning of heavy fall rains or snow. Determination of the relationship between summer evapotranspiration and the various characteristics of the forest site (*4*) may uncover ways to reduce summer water losses.

The soil at some forest sites has such an abundance of stored moisture that evapotranspiration is not limited by lack of available moisture. On these sites it is expected that some patterns of forest cover will be found to use less water than others.

Other forest sites may store less moisture in the soil than could be used by evapotranspiration. On such sites, any type of plant cover would use all the available moisture, and summer evapotranspiration could therefore be reduced only if spring storage of soil moisture were reduced. This might be done through application of forest-cutting patterns that would cause less snow to accumulate in these areas.

Summer losses are being studied on 45 different forest sites. These sites are located on four major series of forest soils, including north and south slopes, steep and gentle slopes, and dense and open forests. The soil series also includes forest openings, bare slopes, and brush-covered areas. Brush, incidentally, is very important, because it covers 26 per cent of the high-elevation watersheds in the Sierra; tree crowns cover only 21 per cent (*5*).

Fig. 2. Snow Zone and Study Areas in the Sierra Nevada

At the points chosen, research is being conducted to determine how water losses can best be minimized.

Summer evapotranspiration losses are determined by a simple and direct method—by measurement of changes in soil moisture. Within a few days after melting of snow, gravitation drains water from the soil and field capacity is reached. If the soil moisture is then measured and then is measured again just before the fall rains, the difference between the two

measurements is the summer evapotranspiration loss. At each of the study sites, soil moisture is measured at field capacity and periodically throughout the summer. These periodic measurements provide information on the rate of evapotranspiration, and guard against the loss of data by misjudgment of the beginning of the fall rains.

Soil moisture is measured with a recently developed radioactive probe at each of the 45 sites. This instrument, when lowered to the desired soil depth in a previously installed, aluminum access tube, obtains quick and accurate measurements and allows remeasurement at exactly the same location and depth. The instrument consists of a probe and a portable scaler. The probe contains radioactive material which emits fast neutrons. Some of these neutrons are slowed down and bounced back toward the probe by hydrogen

Fig. 3. Weighing of Snow Sample in Evaporation Study

The polyethylene container, which fits into a cut in the snowpack, is weighed periodically to determine evaporation losses.

ions in the soil water molecules. The number of slow neutrons returning to the probe per unit of time, measured by the scaler, is directly related to the amount of soil moisture. A few of the first year's results are presented in Table 1.

Winter Losses

Another subject of investigation is the extent of winter water losses, and what forest patterns can be designed to minimize them (*6*). In winter evapotranspiration cannot be calculated from soil moisture changes, as a continuous supply of water is provided by the overlying snow. Instead, the various loss factors must be measured separately—that is, evaporation, transpiration, and interception.

TABLE 1

Water Lost From Soil in Forest Sites During Midsummer, Central Sierra Snow Laboratory, 1958

Type of Forest Site	Aspect	Period	Losses From Top 4 ft of Soil *in.*
Heavy red fir	South	Jul. 23–Oct. 11	5.3
Heavy red fir	North	Jul. 31–Oct. 13	4.8
Bare area	South	Jul. 26–Oct. 20	4.8
Bare area	North	Jul. 23–Oct. 10	3.0
Small forest opening	South	Jul. 21–Oct. 7	5.1

Evaporation

The water lost directly from the snowpack by evaporation is measured in two ways. Direct measurements are possible with small polyethylene pans. A cut snow sample is placed in one of the pans, weighed, and replaced intact into the snow (Fig. 3). At intervals, usually twice a day, the pan is removed with its sample and reweighed. The difference between the two weighings is the evaporation loss. Such direct measurements were taken at the snow "laboratory" last year in a variety of forest and open, nonforest conditions.

To supplement these direct measurements, it is planned to compute evaporation during the winter of 1958–59 by using a gradient equation (*7*) based on temperature, dew point, and wind velocity readings taken at various levels above the snow. An ingenious, portable measuring device developed by the project's meteorologists will be used to obtain readings at many stations.

TABLE 2

Evaporation Losses From Snow, Central Sierra Snow Laboratory, February–June 1958

Month	Evaporation From Snow—*in.*	
	Under Forest Canopy	In Small Clearing
February	0.02	0.09
March	0.05	0.18
April	0.36	0.50
May	−0.04*	0.11
June	−0.05*	−0.03*
Total	0.34	0.85

* Negative data indicate increases in moisture due to condensation.

Some of the evaporation research results thus far have been quite surprising. Unlike the Rocky Mountain region, which has a dry climate and rather large snow evaporation losses (*8*), little water was lost by evaporation from the Sierra snow. In many cases, the snowpack actually gained water through condensation. There are two possible explanations for this: [1] humid maritime winds coming

from the west are cooled and condensed as they pass over the snowfields of the High Sierra; or [2] late in the season, when much of the snow has disappeared, water evaporates from the dark, moist, uncovered soil around snow patches and immediately condenses on the cold surface of the snow. Condensation on a late-season snow patch is shown in Fig. 4.

Evaporation from snow under the forest canopy and in small forest openings was measured in 1958. During the period from February to June, the evaporation loss in a small forest opening was only 0.8 in. Under an adjacent forest the loss was only 0.3 in. A summary is shown by months in Table 2.

The greater evaporation rate during April was caused by a warm east wind that carried a very dry air mass over the Sierras. In the latter part of April the evaporation rate was almost as high at night as during the day. Condensation normally occurred during the night through the rest of the season, especially in the forest.

Several supplementary studies on evaporation were made during this same period. In one study total daily condensation was compared to daytime evaporation and condensation in a large forest opening (Fig. 5).

Interception

Interception by foliage is another cause of winter water loss. Some snow is caught on the trees and lost directly by evaporation, never reaching the snow on the ground. Interception losses are being determined at the snow laboratory by measurements of snowfall in a large forest opening and under the trees of an adjacent forest stand, adding to the latter the snow that drops off the trees and the water that runs down the tree trunks. The difference between the measurement made in the open and in the forest is the interception loss. This method of measuring interception, however, is only valid for wind-free periods. Within the forest stands and adjacent openings, wind and shade are dominant factors in the distribution of snow (*9*).

During a series of late winter storms, from Mar. 5 to Apr. 11, 1958, snowfall under a dense coniferous stand was equivalent to 27.5 in. of water. At

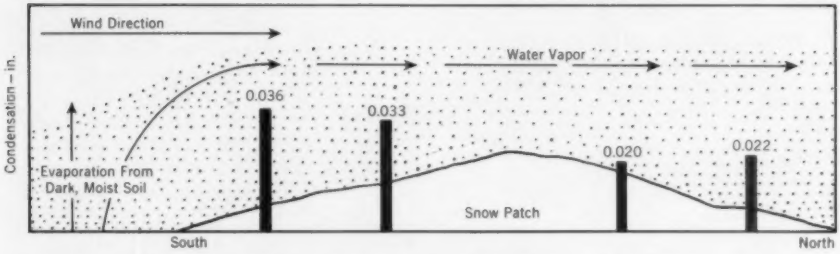

Fig. 4. Condensation on a Summer Snow Patch, 1958

The bar graphs represent condensation gains in 24 hr at four different points on the snow patch. Data were recorded at the Central Sierra Snow Laboratory on Jun. 18–19.

the same time, snowfall in an adjacent forest opening was equivalent to 30.0 in. of water. This is a difference of 8.3 per cent. In an interception study at Bass Lake, Calif., during 1940–46, Rowe and Hendrix (*10*) found similar snow interception losses of 9.8 per cent.

Transpiration

The third part of the winter water loss study is the determination of transpiration losses. Such losses are very difficult to measure satisfactorily, and thus far no accurate method has been found. Present methods of measuring transpiration involve the use of delicate instruments and a setup that is too complicated to use during snow conditions. A new approach is being sought. If, for example, the upward flow of water in a tree trunk could be measured, this would account for most of the transpiration from the tree, and snow would not interfere at all. It may be possible to use electromagnetic or ultrasonic flowmeters similar to those used in measuring flow through pipes; the use of a radioactive tracer or a heat flux meter also seems promising. Experiments with all of these methods are planned for the winter of 1958–59, and it is hoped that a satisfactory means of measuring transpiration will be devised.

Snow studies are well underway. Results thus far promise that evaporation losses can be reduced. Even a small reduction in the water loss from the Sierra's vast snow reservoir, through applied forest land management, could provide significant savings in California's water supplies.

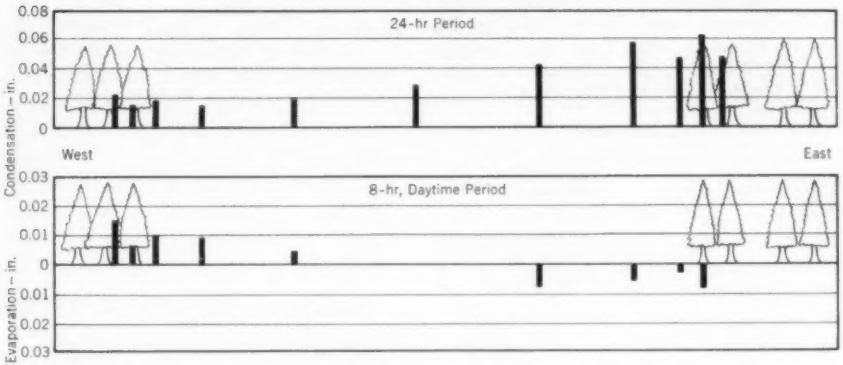

Fig. 5. Evaporation and Condensation Distribution in Forest Clearing, May 18–19, 1958

The clearing was 600 ft wide. As can be seen, the greatest amount of condensation occurred at night.

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Distribution Design Considerations

M. B. McPherson and J. V. Radziul

A paper presented on Jun. 26, 1958, at the Pennsylvania Section Meeting, Erie, Pa., by M. B. McPherson, Research Engr., and J. V. Radziul, Water Distribution Design Engr., both of the Philadelphia Water Dept., Philadelphia, Pa.

THE major part of this article is concerned with balanced pump–network–storage characteristics. A discussion of demand characteristics and of balancing procedures will be illustrated by data and computations taken from a study of Philadelphia's Belmont High-Service District. This district is predominantly residential, having a moderate mercantile development and practically no industry.

Typical Demand Characteristics

The frequency of occurrence of differing demands is an important consideration in any thorough design investigation. In Fig. 1 are plotted the daily demands in the Belmont High Service District for each day of five different years in terms of the respective yearly averages (average-day demand). The ratios of actual daily demand to average day have been arranged in descending order of magnitude, regardless of the actual calendar sequence of their occurrence. The position of any ratio along the horizontal scale thus gives the percentage of the year during which that ratio was either equaled or exceeded. The highest ratio for any given year, occurring less than 1 per cent of the year, is for the maximum day. The lowest ratio, equaled or exceeded 100 per cent of the year, is for the minimum day. The characteristics of each of the 5 years do not differ appreciably from one another (even though the actual numerical average annual rates happen to have a spread of about ±7 per cent).

In Fig. 2 the curve of the daily averages for 1957 from Fig. 1 has been reproduced together with smoothed curves representing the maximum and minimum hours for each corresponding day in 1957. The maximum hourly demand ratio at the extreme left is therefore for the maximum hour of the maximum day. It should be noted that, over a substantial part of the year, the variations in both the maximum and minimum hourly demands are relatively minor. Because of the small variations over the major part of the year for this as well as practically all Philadelphia service districts, design has been based primarily upon the maximum and minimum hourly demands of the maximum and average days.

The coordinates of the 1957 curves in Fig. 3 are somewhat similar to those of the preceding figures, but these curves are for three specific *days* and show the *hourly* variation in demand in terms of the average for the given day. Again, the demand ratio values (here, for each hour) have been ar-

ranged in descending order of magnitude. It is to be especially noted that rates above the average for the day are experienced for 65 per cent (or about 15½ hr) of both the maximum and average days. This happens to be true of the hourly variations for other days of this year with demands between those of the average and maximum days; the "92 per cent of average-day demand" curve represents the typically modified characteristics of a day with a demand lower than the annual average. The characteristics of the maximum- and average-day hourly demands are similar (for this as well as other high-service districts in Philadelphia).

From data similar to those used in Fig. 3, a range of demand ratios for 12 hr out of 24 was determined for other days in 1957, and is represented by the shaded area in Fig. 2. It can be seen that for 50 per cent of the hours in a day times about 80 per cent of the days in a year, or 40 per cent of the hours in a year, the range of demand is only around 0.9–1.3 times the annual average. These figures show the weakness of depending too heavily upon averages and extremes only as design indices, and they emphasize the rarity of extremely high or low demand rates.

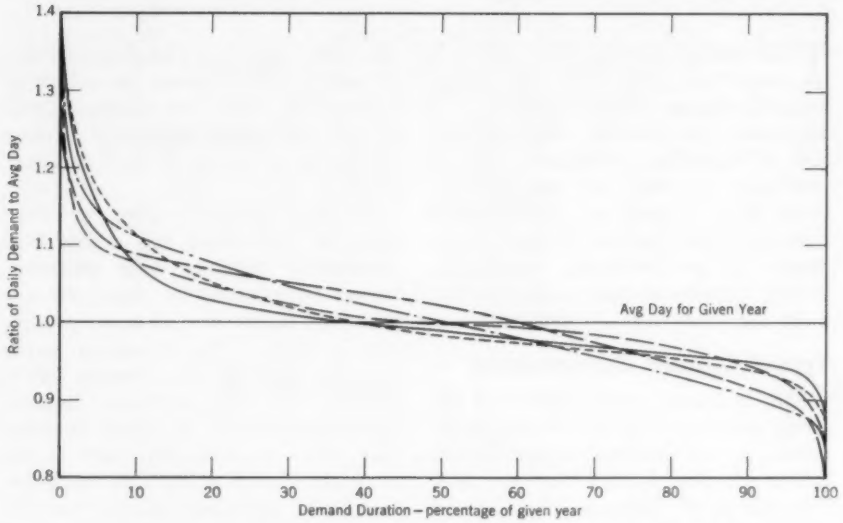

Fig. 1. Daily Demand Distribution for Belmont High-Service District

These curves are based on records for each day of the years 1953–57. Solid curve, 1953; long-short dashed, 1954; short dashed, 1955; long dashed, 1956; dashed-dotted, 1957. Demand duration means here the percentage of the given year during which a particular demand was equaled or exceeded and does not represent a continuous duration.

Balancing of Pump and Equalizing-Storage Characteristics

Excellent papers have been published on procedures for balancing

pumps for demand variations without storage (*1, 2*). In a recent paper (*3*), it was stated that with equalizing storage a step-by-step balancing of storage, demand, and pumping rates was normally neither necessary nor desirable and outlined what had been found to be an expedient design procedure.

The Belmont High Service District will again serve as an example. Elevated storage is to be provided on the extreme west end of the district by 1960. The pumping station is on the opposite, eastern edge of the district. The lowest arterial hydraulic gradient is much closer to the storage site than to the pumping station. In the example, the anticipated 1960 average-day demand schedule will be balanced against a potential 1960 gross storage of 2 mil gal (25-ft maximum operating range).

Anticipated typical 1960 average-day hourly demands are graphed in Fig. 4. The horizontal dashed line represents pumping at a uniform rate of 9.3 mgd (the average demand), which should be approached as nearly as possible for full utilization of the storage and best operation and is the starting point for the balancing procedure. The differences between the uniform pumping rate and the demand curve have been combined and the upper curve represents the resulting storage characteristics. Points A and B were selected as being representative of the probable extremes in hydraulic gradient (for A, 4.2 mgd would go *to* storage; for B, 3.0 mgd would come *from* storage to meet the peak hour). Point A was taken where the storage level would be highest for the largest input to storage and should yield the maximum level of hydraulic gradient at the pumping station.

Next, the network losses for these two extremes were determined. The distribution system loss from pumping station to the tank, the station loss, and the storage and suction water levels were then combined and expressed in terms of the equivalent total dynamic head (TDH) needed to overcome them. The resulting points have been plotted in Fig. 5, together with a pump characteristic curve. The arrows indicate the possible range of the pump curve within which modified values of A and B would have to fall. Arbitrarily revised values A_1 and B_1 were taken midway on each pump curve range. Note that Point A_1 represents a smaller pumping rate than Point A with less flow necessarily going to storage, and Point B_1 represents a larger pumping rate than Point B with less flow from storage. It follows that the volume of storage utilized in the modified case would be less than for uniform pumping.

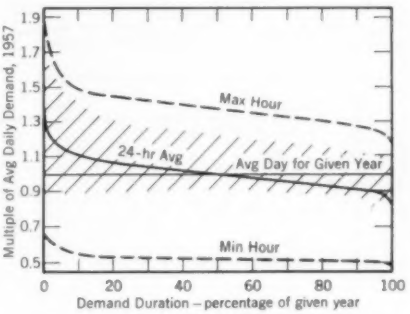

Fig. 2. 1957 Demand Distribution for Belmont High-Service District

The shaded portion of the graph represents the approximate range of demands in 12 of 24 hr.

The next step was to plot the pumping rates for Points A_1 and B_1 on the

demand curve, as shown in Fig. 6. These two first-trial Points A_1 and B_1, alone are not sufficient to define a pumping schedule. The pumping curve must be modified so that the average pumping rate over 24 hr is 9.3 mgd, as in the pumping curve drawn through Points A_1 and B_1. Changing the pumping curve requires recalculation of the storage curve. The revised storage curve should represent equal volumes of output and input and ing between the first-trial equivalent TDH points and the pump characteristic curve, with small adjustments to get the pump and storage curves in balance.

The system characteristics for the second trial, expressed in terms of TDH, are plotted in Fig. 7. Perfect balance would have been achieved had all 24 points fallen on the pump curve. The discrepancies in the second trial are certainly less than the margin of

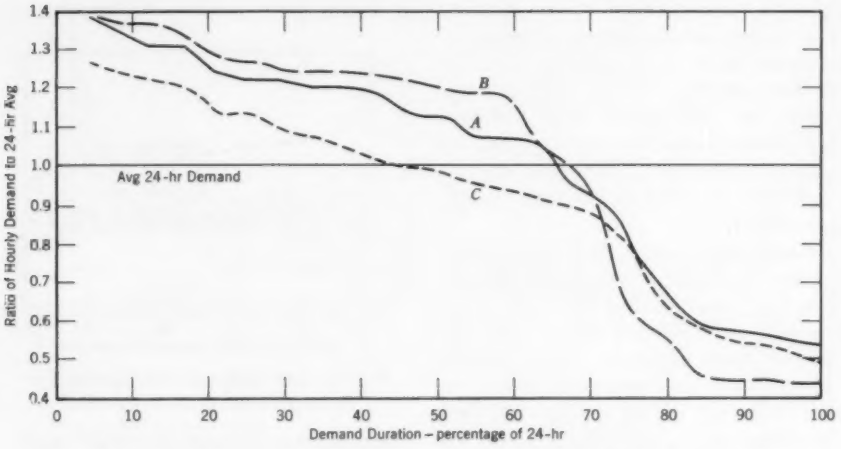

Fig. 3. Hourly Demand Distribution on Average and Maximum Days, 1957

Curves A, B, *and* C *represent, respectively: average day, maximum day, and a day with 92 per cent of average-day demand.*

further adjustment of the pumping curve may be necessary—a trial-and-error procedure. The required equivalent TDH for each hour was then determined for the revised pumping rates and storage rates through system loss calculations. The first-trial results have been omitted for the sake of clarity. The second-trial points A_2 and B_2 and the corresponding pumping schedule were obtained by interpolat-

error in the basic demand data used (for 1960), however, and the second trial could be considered balanced from a practical viewpoint.

Points A_1 and B_1 for the first trial are indicated by arrowheads in Fig. 7 and demonstrate how close the originally assumed range of head was. Had the analysis ceased with the estimated pumping rates for A_1 and B_1, the only significant error would have

been an evaluation of the *lesser* storage requirement, as is intimated in Fig. 6. The difference in storage required between the second-trial and the initial one is 10 per cent of the total usable volume. More imporant, from a hydraulic standpoint, the maximum difference in water level is less than 3 ft. This upholds the principle employed in the procedure used: storage adjustments in themselves have a very small effect on the pump TDH required.

In Fig. 5 Point *B*, the maximum-hour value, is closer to the pump curve than Point *A*, the minimum-hour value. The major reason that a near-balance was achieved in the second trial was this offset; had the pump curve been nearer to *A*, a near-balance might have been impossible. This critical situation is the result, for the most part, of the lopsided distribution of the hourly demands and pumping rates. In Fig. 3 it can be seen that for 65 per cent of the average day the hourly demands were greater than the 24-hr average. The distribution of pumping rates is similar to the demand distribution (Fig. 6). As a result, the position of the pump curve must be about two-thirds of the distance between Points *A* and *B* because about 65 per cent of the points represent pumping rates equal to or greater than the average of 9.3 mgd. (See clustering of points in Fig. 7 near the maximum hour point, B_2.)

This hourly balance study was made possible through the use of the McIlroy network analyzer (*4*). It would not have been attempted without the analyzer because of the tremendous effort and time which would have been required for hand network calculations. Actually, the network analyses for less than half of the 24 points for each trial were needed. In general, for flow to storage, system head loss (station to storage) is a function of the ratio of the pumping rate to the demand rate. When the head loss from the storage site to the point of lowest hydraulic gradient is a substantial fraction of the head loss from the pumping station to the lowest point, it has been found for

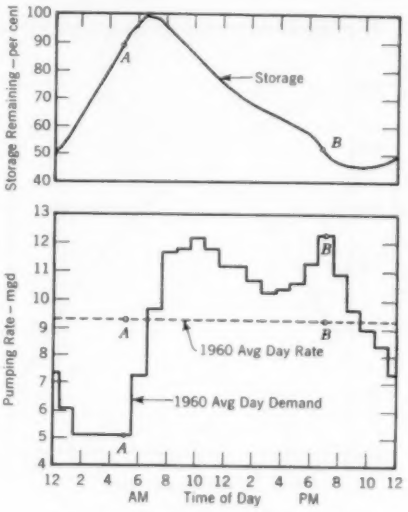

Fig. 4. Initial Condition With Uniform Pumping

The peak of the storage curve represents full storage. Pumping rate is 9.3 mgd. Points A *and* B *represent extremes of TDH needed to meet maximum and minimum demands at this pumping rate.*

these and similar studies that the ratio of station-to-storage head loss to the rate out of storage is a function of the ratio of the pumping rate to the demand rate. System head losses for over half of the 24-hour combinations were therefore read from plots of the above functions developed from the

network analyses, thereby reducing the work substantially.

In Fig. 8 are plotted the extreme values for balanced characteristics for the average day, Points A_3 and B_3, interpolated from Fig. 7. The heavy band on the pump curve is the approximate range of values which would obtain for 80 per cent of the year, utilizing storage. With storage, a single pump can often handle a major share of the year's demands. For contrast, also shown are the equivalent points, A_4 and B_4, for direct pumping without storage. For the latter, as a means of comparison, the equivalent TDH were made such as to provide the same pressure at the point of highest elevation as for Points A_3 and B_3. The hydraulic gradients of these four points are plotted schematically in Fig. 9. Even though the same pressure is compared at the point of highest elevation in both cases, the point of lowest hydraulic gradient would suffer a much larger swing in pressure without storage. The filtered-water basin water levels are somewhat hypothetical inasmuch as the pumping station is to be moved to a nearby location, with the exact location and suction source still to be determined.

In Fig. 10 a hypothetical storage characteristic curve is drawn for an average-demand day of 9.3 mgd. This

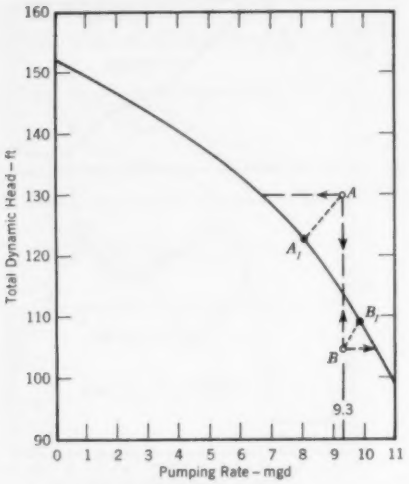

Fig. 5. Adjustment to Pump Characteristic Curve

Points A *and* B *represent extremes of TDH needed to meet maximum and minimum demands at a uniform pumping rate.* A_1 *and* B_1 *are these points for the first trial.*

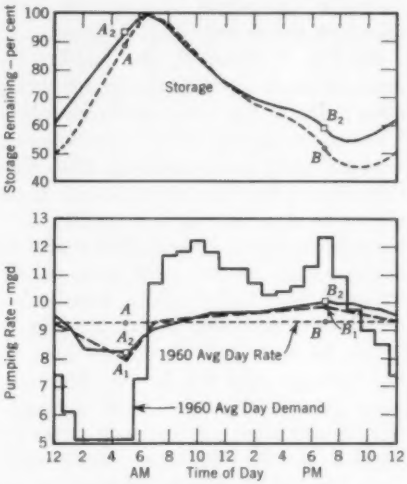

Fig. 6. Balancing of Storage, Pump, and Network Characteristics, First and Second Trials

Storage curves: the solid and dashed curves represent the second trial and uniform pumping, respectively. Pumping curves: the solid and dashed curves represent the second and first trials, respectively.

curve was constructed by determining the volume between successive assumed pumping rates and the demand curve of Fig. 4, using constant pumping rates of 9.3 mgd and higher. For uniform pumping at 9.3 mgd, which is the same as the condition in Fig. 4, 1.10 mil gal of storage (0.118 times 9.3) is needed theoretically. If the entire maximum hour were to be met by pumping, the pumping rate would be 1.33 times 9.3 mgd. The graphs presented on near-balanced conditions have shown that a constant pumping rate for a variable demand was approached but not attained. As a result, pumping rates both greater and less than the average were indicated; less storage would be necessary than indicated for uniform pumping. These effects are reflected in the position of the point plotted in Fig. 10 for the conditions of the second, and final, balancing trial (Fig. 6).

The approximate evaluation of storage volume requirements through assumed uniform pumping will yield a larger calculated volume for the given demand curve than could actually be utilized.

The network for which these system characteristics were determined does not represent the final piping arrangement planned for 1960; it represents a possible interim condition during re-

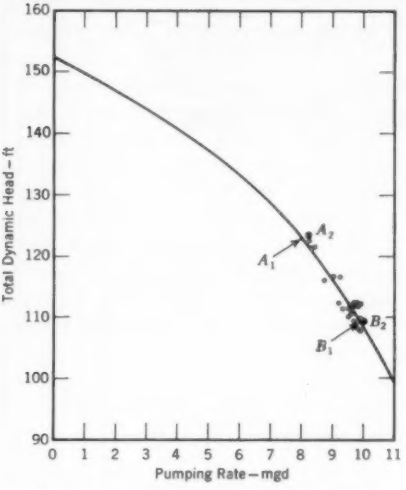

Fig. 7. Pump Characteristic Curve, Second Trial

The plotted points represent each of the 24 hr in the second trial (see Fig. 6)—that is, demand, storage, and pumping rate. For each combination, network losses were determined first, then TDH.

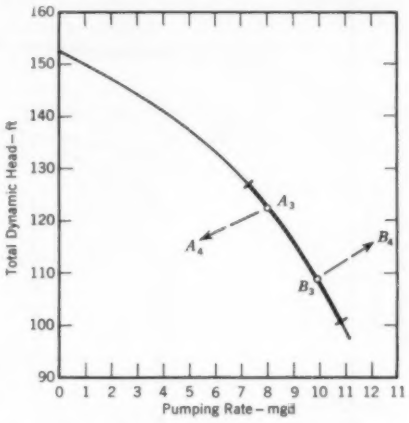

Fig. 8. Near-Uniform Pumping With Storage and Pumping Without Storage

The heavy portion of the curve represents the pumping range for 80 per cent of the year (Fig. 2) with storage. Without storage, the same percentage of the year would require a range of 4.8–13.8 mgd. Points A_4 *and* B_4 *(without storage) are for the same pressure (at highest elevation) as* A_3 *and* B_3.

The network for which these system characteristics were determined does not represent the final piping arrangement planned for 1960; it represents a possible interim condition during re-

habilitation of the system and was used because the range provided by the relatively high system head losses leads to a more vivid illustration of the balancing procedure. A 2-mil gal storage capacity for this system is quite marginal and will provide only nominal peak demand, outage, and fire flow relief. Too many complications would by peak consumption rates, whereas the design of local grids and very small separate service districts is often dependent upon fire demands. As a concomitant to modern city planning, there is an urgent need for a critical revaluation of the design criteria for local distribution grids in terms of present and future factors. Each

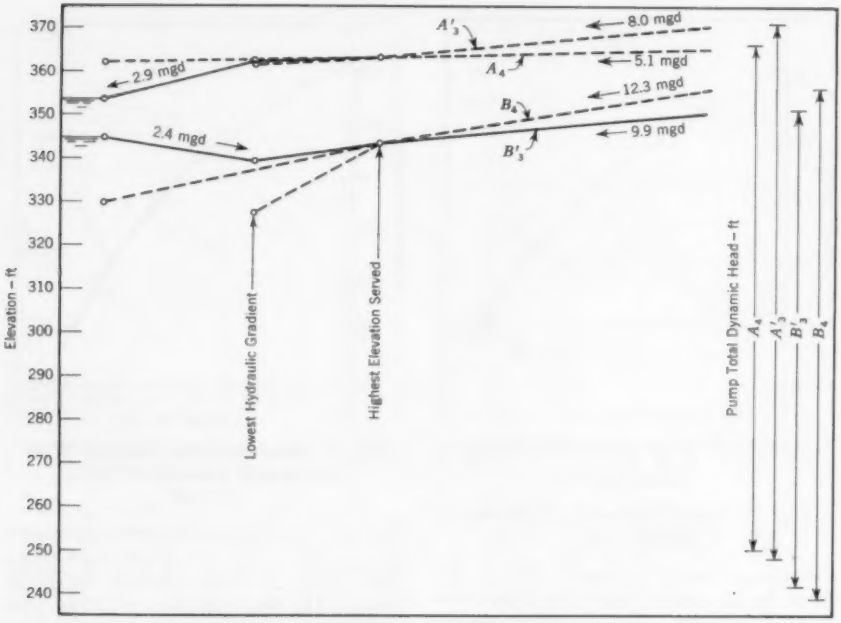

Fig. 9. Hydraulic Gradients With and Without Storage

Although the same pressure is compared at the point of highest elevation both with and without storage, the point of lowest gradient would undergo a larger swing in pressure without storage.

have been involved in an illustration using maximum-day demands with a marginal storage capacity, or in using demands projected beyond 1960.

Local Grid Design

In a large city the design capacity of arterial mains is generally governed water main laid normally constitutes a fixed component of the distribution system of the next 50–100 years. The distribution system of most water utilities comprises the largest item of cost.

Good judgment and sound design criteria are paramount if adequate and satisfactory customer service is to be

provided at minimum capital outlay. Although there are basic kinds of considerations and general principles of good design, local conditions must determine the approach in each case. For instance, in the design of a local residential grid the street pattern, zoning, saturation population, consumption rates, fire demands, location of arterial supply mains, and hydraulic characteristics of the arterial supply mains at points of input into the local grid must be considered.

In the modern concept of city planning, what is considered basic and essential to good living conditions, insofar as the layout of the street system is concerned, is not necessarily conducive to the establishment of a sound water distribution grid. Modern residential street layouts emphasize and encourage privacy. Consequently, through-traffic streets are kept to a minimum and streets are long and winding with few points of intersection. This street pattern complicates the development of a strong hydraulic grid system.

Figure 11 shows a typical street layout for a new Philadelphia residential development. The reinforcement inherent in a crisscross grid pattern cannot be provided. Note also that few points of connection to the main arterial supply can be made. Nevertheless these are typical of the conditions which may be encountered in the newer, planned areas.

Another feature, designed for privacy but objectionable from a water distribution viewpoint, is the *cul-de-sac*. Most residential *cul-de-sac* streets can readily be serviced with 2–3-in. mains, depending upon the number of customers and the length of run, and fire service can usually be provided from the larger main in the abutting access street if the fire hose run is not excessively long. On the other hand, more long *cul-de-sac* streets are to be expected, perhaps with added fire service design handicaps such as schools or residential hotels. These may often be overcome by using a larger main or by obtaining a right of way through private property to tie the end of the *cul-de-sac* main into the local grid (dead-ended 6-in. mains used for fire service are subject to NBFU deficiency points).

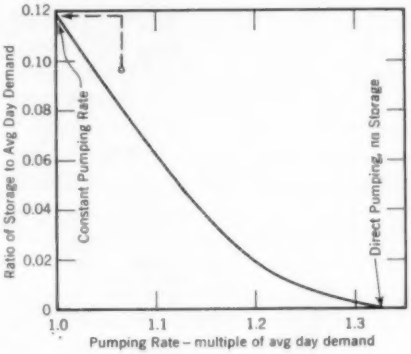

Fig. 10. Hypothetical Curve for Demand Day of 9.3 mgd

The plotted point represents the second trial with 2 mil gal storage (see Fig. 4, 6).

There are other features of a modern residential street layout that could be discussed. The prudent water department should have a designer sit in on the board of review of the city planning commission in an advisory capacity when the layout of new street systems is being discussed.

The designer can determine much about the probable water requirements of a new residential development through its zoning classification and the trends in types of building con-

struction in his area. These factors should enable him to make a fair estimate of the saturation population of the development and arrive at appropriate consumption figures. In addition, he should be able to resolve the probable fire service requirements on the basis of these factors.

Wolff (*5*) recommends that for the 20-year period between 1955 and 1975, an *annual* increase of 2 per cent per capita per day be utilized in the design of residential water distribution systems because of the tremendous potential for increased utilization of water-using equipment in homes.

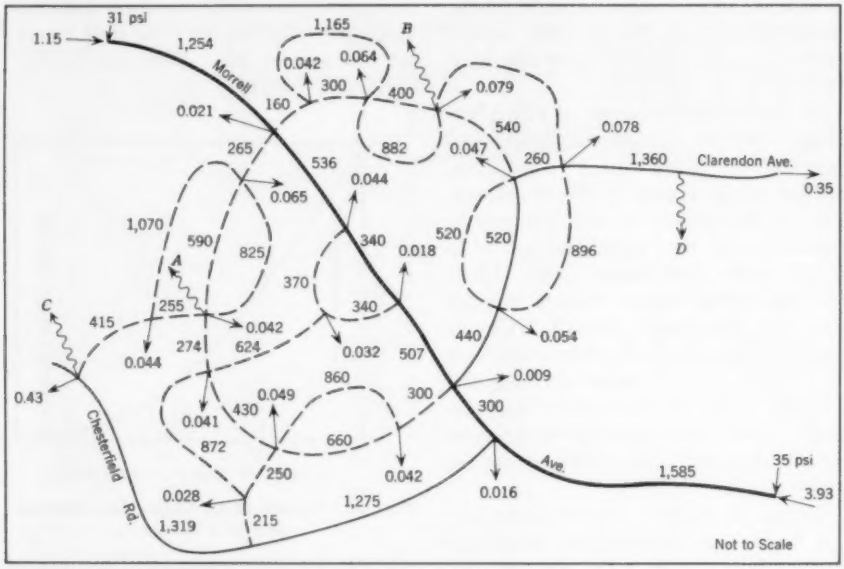

Fig. 11. Street Layout for Residential Development and Summary of Fire Flow Tests Made During Delivery of Maximum-Day Demand

Layout: The heavy, light, and broken lines represent 16-, 12-, and 8-in. mains, respectively. C values are 130, 110, and 100, respectively. Lengths are in feet. Fire Flow tests: Flows of 2,500 gpm were taken at Points A, B, C *and* D; *residual pressures at these points were 21, 20, 16, and 15 psi, respectively. Shown also are maximum day demands in millions of gallons per day.*

The rising standard of living leads directly to the use of additional water-consuming devices in homes. There is no doubt that the number of dishwashers, washing machines, garbage disposal units and water-cooled air conditioners is increasing each year.

There is much in the literature concerning residential consumption and rates which could be used by the designer either in forecasting or in design. The rates reported by Aldrich (*6*) after a survey of approximately 130 communities in the northeastern

United States with up to 50 mgd annual average usage, are very similar to those in the Philadelphia high-service districts that have been studied by the authors. Most water departments have abundant data pertinent to water use within their own systems. Particular attention should be given to the peak hour because in some predominantly residential areas it may be as high as 400–500 per cent of the average daily demand (*5*). At these large peak rates, fire flow demands will probably seldom govern the design of the local distribution system.

The policies and regulations of a water department have an important bearing on the design of a local distribution grid. Of what use is a guarantee of a minimum service pressure at the curb if regulations permit the installation of undersized service lines and fittings? A study by Arnold (*7*) on friction losses in service lines and fittings points out the need for improved service facilities and a revision in the policies and regulations of water departments if the type of service the customer demands is to be attained at reasonable cost.

The following data illustrate peak hour and fire demand requirements using rates anticipated for the year 1960 in the district under consideration.

Item	Requirement *mgd*
Average day	9.3
Maximum day	13.9
Maximum hour of maximum day	19.9
Maximum fire flow	6.0
Maximum day plus fire flow	19.9

By sheer coincidence the demand rate for maximum hour of the maximum day exactly equals the maximum day rate plus the maximum fire flow rate. If the district were a separate community with a high-value district, the maximum day rate plus maximum fire flow would be 13.9 mgd plus 120 mgd, or 25.9 mgd. This higher rate would then govern the design of the arterial mains, at least in the high-value district. Regardless of city size, the maximum fire flow requirement for residential districts is 8.6 mgd. Fire flow requirements in other than the high-value district are of course appraised by the NBFU mostly on the basis of structural conditions and congestion of buildings. Conversely, a heavy peak hour consumption imposed on a local residential grid could govern its design instead of fire flow demands.

The effect of fire flow and peak hour demands on local grid pressures will be illustrated with the results from analyses for a new row-house development now under construction in Philadelphia. Hydraulic characteristics were obtained directly through use of the water department's McIlroy network analyzer.

At the present time, regulations for the installation of new water service lines fix ¾ in. as the minimum size allowable. The policy with regard to service pressure is to provide at least 30 psi at the curb during the peak hour rate. The minimum residual pressure prescribed by the NBFU for Philadelphia, when the required fire flow is being drawn, is 10 psi.

The rates used for the residential grid study are as shown below.

Item	Rate *gpcd*	Percentage of Average Annual Rate
Average annual	125	100
Maximum day	177	142
Peak hour	250	200

From the zoning of the area, an esti-

mate of 1,640 dwelling units was made. City planning statistics aided in determining the probable saturation population of 6,600 persons or approximately four per dwelling unit. A fire flow requirement of 2,500 gpm was predicted on the basis of zoning and by comparison with established fire grading for similar areas in Philadelphia.

large cities today (*8*). A Hazen-Williams *C* value of 110 for a 12-in. main may appear to be high, but most tests of 12-in. cement-lined pipe throughout the system indicate *C* values well above 110.

Figure 12 gives the hydraulic characteristics of the final grid under estimated peak-hour conditions. Indicated

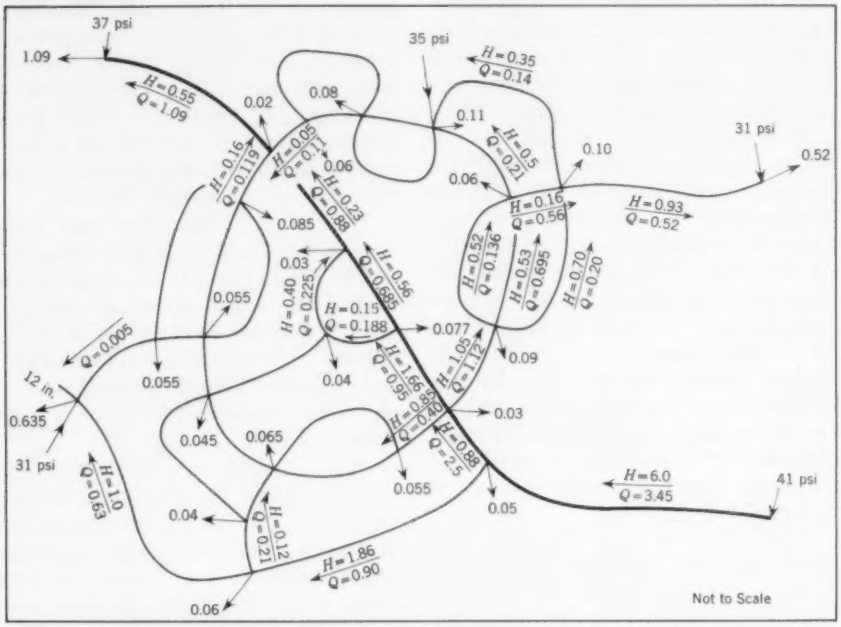

Fig. 12. Hydraulic Characteristics of Grid Under Estimated Peak-Hour Conditions

All flows are in millions of gallons per day.

The layout of this sector is given in Fig. 11, and the pipe sizes shown are the final design sizes. All *cul-de-sac* streets were omitted from the drawing for simplicity. Philadelphia's policy fixes 8 in. as the minimum main size in any new development; this is in accord with the policy trend in many

are the loads, flows, head losses, and the pressures at critical points in the grid. The arterial pressures of 41 psi and 37 psi and the inflow of 3.45 mgd shown for the 16-in. main were determined previously in separate analyzer studies of the arterial supply system. The initial grid, which was composed

entirely of 8-in. mains, proved to be inadequate. Secondary, 12-in. feeder mains were then substituted for some of the 8-in. mains until the most economical arrangement was obtained while just satisfying the basic design criteria of a minimum of 30 psi. For this study condition, the pipes were considered to be large enough to preclude excessive pressure drops and serious water hammer effects.

The separate arterial supply main study also furnished the necessary hydraulic data at the input points when the required local fire flow was being delivered simultaneously with the maximum-day demand in the entire service district. Figure 11 summarizes the results of some of the fire flow tests that were made. The final distribution grid was found to be adequate; any decrease in pipe size resulted in fire flow deficiencies. As previously noted, with the final piping layout, the peak hour demands were met with marginally satisfactory service pressures. Hence, for this grid, both the fire and peak hour demand conditions could be regarded as pipe size criteria. Had the estimated peak hour demands been larger, the fire demand would not have had any significant influence on the design.

With the analyzer, a very thorough study resulting in the most economical design was made possible in a fraction of the time that would have been required for appraisals by conventional methods. In addition, the designer was able to evaluate the entire grid and check the effects of changes throughout the grid pattern. He could determine with certainty whether or not fire flows would create negative pressures in sectors other than the fire test area; this is not particularly apparent when using the method of sections or the circle method. Until one has used computers or analyzers in network design it may be difficult to appreciate the economies which they afford. Therefore, any revaluation of design criteria should be augmented by a review of design techniques and design tools.

Conclusion

The possible strategic importance of the "average day rate" pump in a system with equalizing storage has been made evident. The contribution of detailed analyses of hour-by-hour and day-by-day demand rates to design has been emphasized.

A demonstration of balanced storage and demand and pumping rates has been shown to be closely approximated by an initially estimated pump characteristic range. For near achievement of balance, however, there is need for a pump characteristic which has the inherent capacity of balancing with the given system and storage characteristics. The technique used to approach balanced characteristics was based on the fact that the storage water levels for different trials for a given hour usually fall within a very small range of elevation, despite considerable modification of the pumping schedule from trial to trial.

Storage volumes derived under the simplifying assumption of constant pumping rates have been shown to be somewhat greater than the requirements for the actual case of near-uniform pumping, when the pump capacity range is not small.

Recent developments in city planning procedure and water supply practice require a thorough revaluation of criteria for local grid design.

Network calculations can now be performed with reasonable exactitude by means of computers or analyzers; there remains little valid excuse for perfunctory local grid design or the continued use of outmoded shortcuts.

Acknowledgment

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Hydrologic Interrelations of Ground and Surface Waters at Lafayette

Joseph S. Rosenshein

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INCREASING demand is being placed upon Indiana water resources by industries and municipalities. Irrigation is rapidly becoming an important application of both ground water and surface water in the state and eventually will become one of the larger uses of these resources. In order to plan for wiser utilization and proper development and conservation of water resources in the future, it is necessary to have a better understanding of the basic interrelations of ground water and surface water. The need for intelligent understanding of these interrelations has been emphasized by the recent trend toward state control of Indiana's water resources.

Hydrologic Conditions

The perennial changes in ground water level and river stages are related to precipitation. In Indiana most of the recharge to the ground water reservoir is derived from local precipitation. Under natural conditions, therefore, long-term and short-term variations in precipitation cause changes in water level in a ground water reservoir. During long periods of above-average precipitation the ground water levels are high, and during long periods of below-average precipitation they are low. These levels also reflect short-term trends caused by seasonal variations in the rate, and differences in the amount, of recharge and discharge. Ground water levels generally are highest during late winter and early spring. They start their seasonal decline at the beginning of the growing season and continue this decline until late fall. This downward trend is the result of increased use of precipitation by vegetation and discharge through evapotranspiration before appreciable amounts of the precipitation can percolate downward to recharge the ground water reservoir.

River stage and flow also are greatly affected by precipitation. River stages react more quickly to precipitation than do ground water levels, and the changes caused by heavy precipitation are generally of greater magnitude and shorter duration. During periods of heavy precipitation much of the stream flow is derived directly from surface runoff within the stream's drainage basin. During dry seasons, however, much of the flow is derived from effluent seepage from the ground water reservoir. This effluent seepage forms

Fig. 1. Location of Observation Well Tippecanoe 4, Lafayette, Ind.

All observation points discussed in the text are indicated on this map (not to scale).

the base flow of a stream. Thus, the streams in Indiana serve as one of the important agents of natural ground water discharge. Local factors, such as heavy pumping, greatly affect the natural ground water discharge and, therefore, directly or indirectly affect the stream flow and river stage (*1*). The effect of these factors may or may not be delayed for a long time, depending on the distance of the pumping area from the stream and the geologic and hydraulic characteristics of the ground water reservoir.

Conditions at Lafayette

The geologic and hydrologic conditions at Lafayette have been chosen as an example of the interrelation of ground water and surface water. These conditions are described in another paper (*2*). Ground water in the

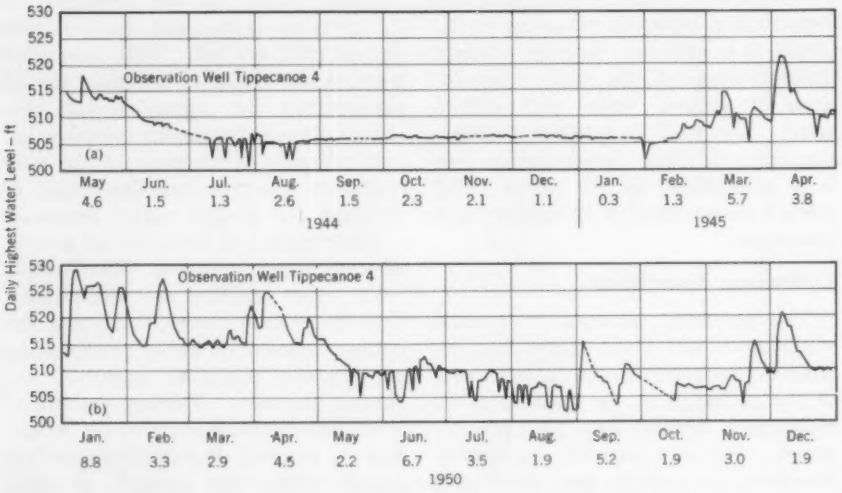

Fig. 2. Daily Highest Water Levels in Observation Well Tippicanoe 4 and Total Monthly Precipitation at West Lafayette

Precipitation data are given under each month and are expressed in inches. Parts a *and* b *represent relatively dry and wet periods, respectively. Water levels are in feet above mean sea level.*

Lafayette area is obtained from wells drilled into glaciofluvial sand and gravel. These sand and gravel deposits have been breached locally by the Wabash River. In the vicinity of Lafayette, ground water in these deposits occurs under artesian conditions. North and west of the Wabash River, however, in the West Lafayette area, water table conditions prevail. The natural hydraulic gradient within both the artesian and the water table parts of the aquifer is toward the Wabash River, which serves as the chief agent of ground water discharge from the aquifer. Changes in the water level in this aquifer are reflected by changes in the water level in observation well Tippecanoe 4. This observation well is at the Canal Street pumping station in Lafayette. Changes in the stage of the nearby Wabash River are recorded by a gaging station at the Brown Street bridge in Lafayette. Figure 1 shows the location of observation well Tippecanoe 4, the Canal Street well field, and the gaging station on the Wabash River.

Precipitation and Ground Water Levels

The data obtained from the observation well and the gaging station were used to prepare hydrographs to show the effect of various factors upon both ground water level and river stage.

The records for a relatively wet period, January through December 1950,

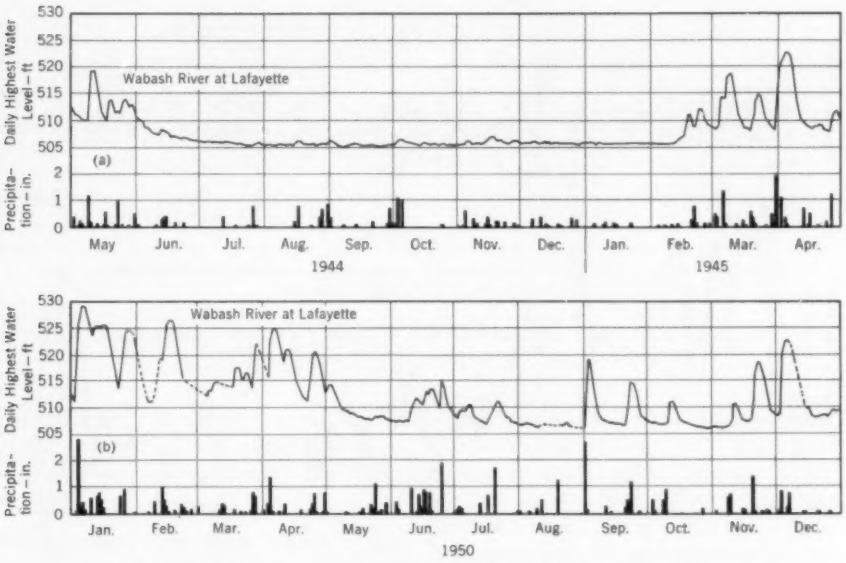

Fig. 3. Daily Highest Water Level in Wabash River at Lafayette and Monthly Precipitation at West Lafayette

Parts a *and* b *represent relatively dry and wet periods, respectively. Water levels are expressed in feet above mean sea level.*

and for a relatively dry period, May 1944 through April 1945, are used for comparison. The water levels in the observation well show seasonal variations that are related to precipitation (Fig. 2). The water levels were relatively high but were declining during late spring. Heavy precipitation causes only a small, temporary reversal in this downward trend during the summer months, owing to the evapotranspiration of precipitation. The recovery of the water levels for the 1950 period began in the late fall. At this time of

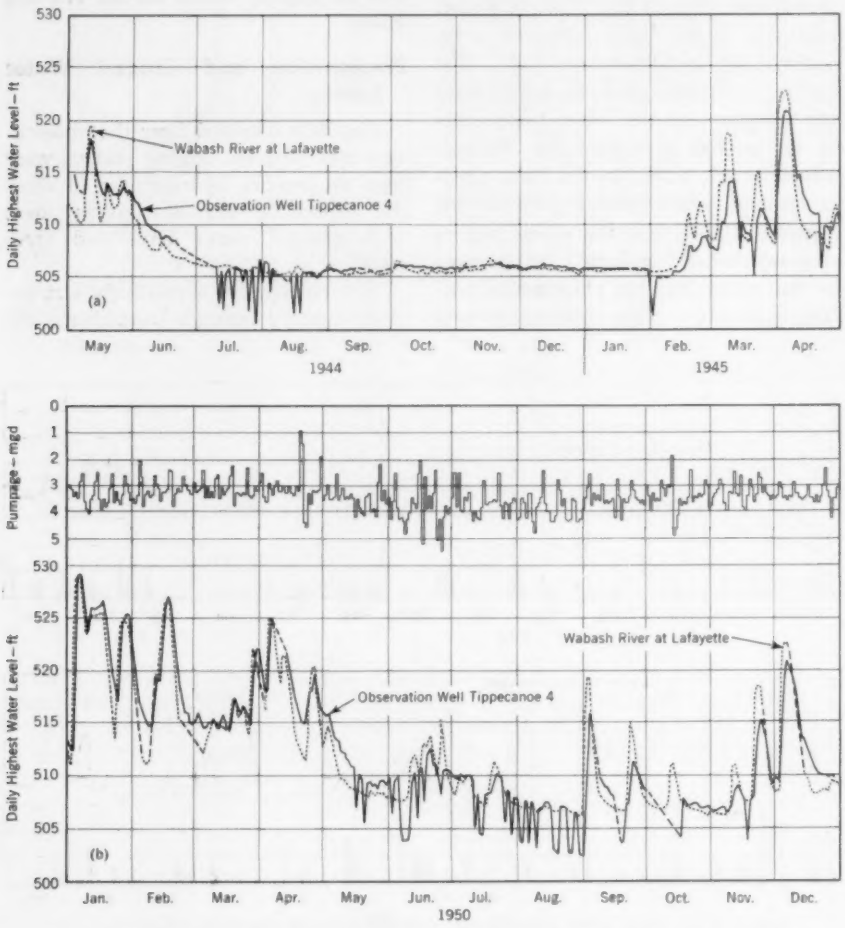

Fig. 4. Pumpage at Canal Street Well Field and Daily Highest Water Levels in Observation Well Tippicanoe 4 and in Wabash River at Lafayette

Parts a *and* b *represent relatively dry and wet periods, respectively. Water levels are expressed in feet above mean sea level.*

year small amounts of precipitation result in major changes in the water levels. Water levels during the dry period from 1944 to 1945 did not recover until late winter, however, owing to the prolonged lack of heavy precipitation and to continued deficiency in soil moisture. In addition to these seasonal trends, the water levels for the 1950 period were higher than comparable water levels for the 1944–45 period, which shows the overall effect of the several years of relatively heavy precipitation that preceded the 1950 period.

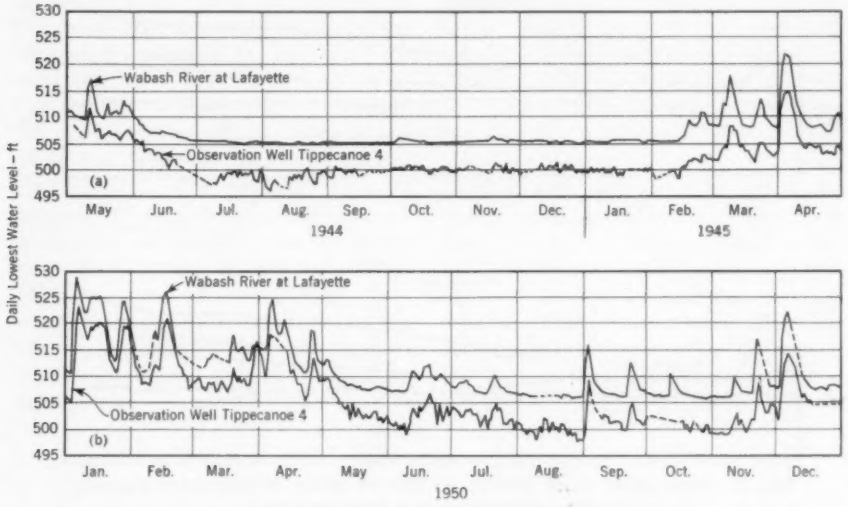

Fig. 5. Daily Lowest Water Levels in Observation Well Tippicanoe 4 and in Wabash River at Lafayette

Parts a *and* b *represent relatively dry and wet periods, respectively. Water levels are expressed in feet above mean sea level.*

Precipitation and River Stage

The river stage of the Wabash River at Lafayette is generally higher at other times than the growing season (Fig. 3). Heavy daily precipitation causes rapid rises in the river stage. The river stage continues to rise several days after precipitation has stopped, as surface runoff from the tributary streams in the part of the drainage basin above the gaging station discharges into the river. Heavy precipitation during the growing season does not have as great an effect upon the river stage as it does at other times. This relation is shown by a comparison of precipitation and river stage in April 1950 with that in June 1950. Less precipitation was required in April than in June to produce an equivalent or greater rise in the river stage. This difference was in part a result of the higher rate of evapotranspiration in June than in April, and it is an indication of the quantity of water used by the evapotranspiration process. These

same relations apply to the dry period from May 1944 to April 1945, except that occasional heavy daily precipitation resulted in only minor changes in the stage of the Wabash River. The fluctuations in river stage for 1950 were generally similar to the fluctuations in ground water levels at Lafayette. The river stage for 1950 was higher than for the 1944–45 period, which shows the overall effect of the gradient of the piezometric surface is nearly always toward the Wabash River. This gradient is not as steep during the growing season, indicating that the effluent ground-water discharge to the stream is greatest in the other seasons. During a prolonged dry spell such as from July 1944 through January 1945, the hydraulic gradient toward the river is relatively level; therefore the ground water discharge

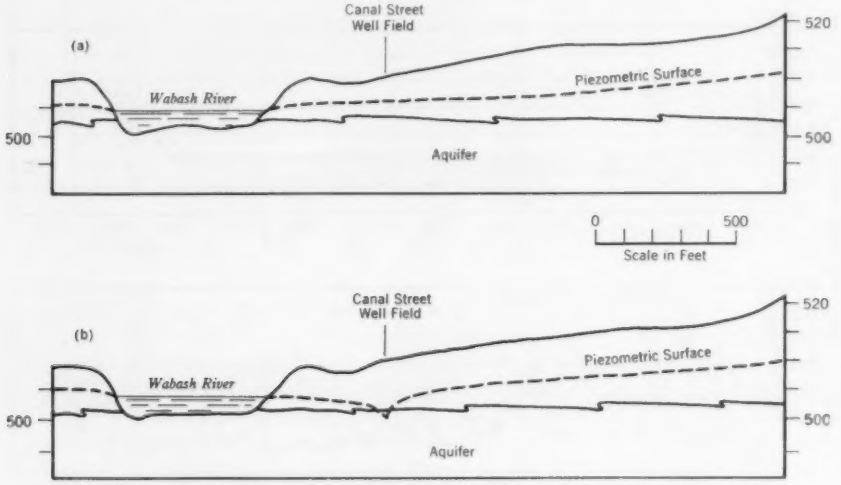

Fig. 6. Generalized Cross Section of Wabash River at Lafayette Showing Natural Conditions and With Pumping

Part a *shows the natural hydrologic conditions near the Canal Street well field at Lafayette. Part* b *shows the effects of pumping; note the lowering of the piezometric surface, resulting in a diversion of ground water that would normally discharge into the river. Vertical distances are in feet above mean sea level.*

several years of relatively high precipitation which preceded 1950.

River Stage and Ground Water Levels

A comparison of the highest daily water level in observation well Tippecanoe 4 and the highest daily recorded level of the Wabash River at Lafayette (Fig. 4) shows that the natural is relatively small, even though practically all the flow of the river is effluent ground water.

The water level in observation well Tippecanoe 4 reflects daily changes in the stage of the Wabash River. Rapid changes in the river stage owing to heavy precipitation cause corresponding changes in the water level in the observation well. The changes in

ground water level are of smaller magnitude than the changes in river stage but of about the same duration. At that time the natural hydraulic gradient adjacent to the stream is reversed —an influent condition—and water moves temporarily from the river into the aquifer.

Effect of Pumping

Pumping in the Canal Street well field markedly affects the water level in observation well Tippecanoe 4. The well field begins daily operation between 6 AM and 8 AM and may continue operation until 10 PM, or later. This typical pumping pattern is modified during the months of heavy usage, when the wells are pumped almost continuously. The greatest effect of pumping on ground water levels occurs at the time of naturally low levels and river stages—that is, generally from late spring through late summer. Figure 4 shows the daily pumpage and the effect of pumping upon the highest daily water level in the observation well for the 1950 period. Increases in daily pumpage cause lower daily water levels in the observation well. With decreases in pumpage the water level in the well resumes its natural trend.

Hydrographs of the relation between the lowest daily water level in the observation well and the lowest daily river stage (Fig. 5) show that heavy pumping causes the water level in the observation well to decline below the stage of the river. Thus, the piezometric surface, which under nonpumping conditions slopes toward the river, is reversed for some distance from the well field. Figure 6 presents two generalized cross sections showing natural hydrologic conditions and the effect of pumping upon the hydraulic gradient in the aquifer. Owing to this change in gradient, the pumping results in a diversion of the ground water which normally would be discharged to the Wabash River. This diversion is equivalent in effect to a direct removal of water from the stream and results in a decrease in flow. Part of this water, of course, returns to the river as sewage effluent some distance downstream, but the net effect is a decrease in flow. If the effect of pumping is sufficient to reverse the gradient over the entire distance from the well field to the river, then some water will be contributed directly by the river through induced infiltration (*3, 4*), provided a hydraulic connection exists between the aquifer and the Wabash River. Hydrologic and subsurface geologic data indicate that this condition prevails at Lafayette. Additional data, which were obtained in September 1957 from test drilling and a pumping test, further substantiate this contention. These data show that the water level in the aquifer at a point 260 ft east of the river is 2 ft below river stage when the well field is operating.

Conclusions

The general hydrologic interrelations described in this paper are not peculiar to the Lafayette area. Similar conditions exist at other localities along the larger streams of Indiana. The effect of heavy pumping of wells upon streams, or other surface water bodies, depends on the distance of the wells from the surface water, as well as on the geologic and hydrologic conditions within the pumping area. In practical application, well fields are established near streams in order that a readily available source of recharge may be utilized, either by directly withdrawing water from the stream by induced in-

filtration, under favorable conditions, or by diverting part of the ground water contribution to the stream. The net result is the same. Therefore, it is not necessary to pump water directly from a stream in order to decrease its flow. Because of the interrelations of ground water and surface water, ground-water hydrology must be considered in evaluating the factors affecting stream flow. These same hydrologic interrelations must be taken into consideration in any attempt to formulate legislative controls of diversion of ground and surface water.

References

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Job Evaluation of Water and Sewage Treatment Plants in Florida

Lester J. Turvaville

A paper presented on Oct. 20, 1958, at the Florida Section Meeting, Miami Beach, Fla., by Lester J. Turvaville, Industrial Sales Engr., Tampa Electric Co., Tampa, Fla.

AS part of the author's thesis for a master of science degree in engineering at the University of Florida, Gainesville, he was engaged in a study of jobs at selected sewage treatment plants. To make the study more generally useful, he was requested to expand the study to determine the relative value of the jobs in both water and sewage treatment plants and to establish minimum and maximum salaries for these jobs based on their relative worth. As a result, a job evaluation study was conducted on nine sewage and three water treatment plants of various types and sizes in Florida.

Job evaluation is the ranking or grading of jobs in some systematic way to ascertain the labor worth of each job relative to all of the others. The method which was followed in this study was the point-rating method. It is presented in this article in a step-by-step order exactly as it was performed by the author.

Point Rating

Fundamentally, in the point-rating method the characteristics of a job are compared with a set of standards or definitions and points are awarded in proportion to the degree to which the requirements and conditions measuring the worth of the job are present.

In the first stage of this method the jobs to be evaluated are studied to determine the characteristics and factors to be used in measuring job worth. The characteristics and factors used in this study were:

1. *Skill.* The factors considered in evaluating skill were education, experience, and initiative or ability.
2. *Effort.* The factors considered in evaluating effort were physical demand and mental or visual demand.
3. *Responsibility.* The factors considered in evaluating responsibility were equipment, material, safety of others, and work of others.
4. *Job conditions.* The factors considered in evaluating job conditions were work conditions and hazards.

The maximum and minimum possible degree of presence of each factor was studied so that all jobs to be evaluated would fall within the degrees selected and no unnecessary degree would be provided.

The weight to be assigned to each characteristic, factor, and degree was then decided. This is called the basis of ratings. The basis used in this study was the same as the basis used by the University of Florida for semi-skilled and technical jobs. It is shown in Table 1.

TABLE 1

Basis of Point Rating

Factor	Degree	Point Rating
Education	4 years of college	140
	algebraic and trigonometric applications; technical reports (equivalent to 2 years college or graduate technical institute)	120
	advanced shop mathematics; develop formulas; make or read fairly complicated drawings; assist on technical reports (equivalent to high school graduate)	112
	writing or reading of simple reports; handling fractions, simple graphs, and formulas (equivalent to 2 years of high school)	84
	read and write readily; handle simple arithmetic (equivalent to grade school graduate)	56
	minimum ability to read and write; add and subtract simple numbers	28
	no education required	0
Experience	4 years or more	220
	2–4 years	176
	1–2 years	132
	3 months–1 year	88
	1 week–3 months	44
	less than 1 week	22
Ability	outstanding ability to achieve successful results on complex jobs	140
	superior ability to achieve successful results on jobs that are somewhat complex	112
	ability to plan and perform a sequence of operations when recognized operation methods are available	84
	ability to work from detailed instructions and make minor decisions	56
	little or no initiative required; employee expected to follow simple instructions	28
Physical demand	continuous, heavy physical effort or intermittent with severe strain	100
	considerable physical effort or continuous strain of difficult work position	80
	continuous physical activity with light- or average-weight materials	60

TABLE 1 (*contd.*)

Basis of Point Rating

Factor	Degree	Point Rating
Physical demand (contd.)	light physical effort with lightweight materials*	40
	very light work requiring little physical effort	20
Mental or visual demand	highly concentrated attention on very complex jobs	50
	concentrated attention to complex jobs, or manual dexterity with close visual attention for sustained periods	40
	continuous attention on repetitive work requiring constant alertness	30
	frequent attention but intermittent work flow (machine needs little attention)	20
	little mental and only intermittent visual attention on practically automatic operation requiring attention only at long intervals	10
Equipment or process	possible loss caused by employee very high (to $2,000)	50
	probable loss caused by employee high (to $500)	40
	probable loss caused by employee limited (to $250)	30
	probable loss caused by employee low (to $100)	20
	possibility of loss or damage slight ($10 or less)	10
Safety of others	heavy obligation for health and safety of many others	50
	heavy obligation for health and safety of a few others	40
	carelessness may cause injury to another	30
	not much chance for injury to another	20
	practically no chance for injury to another	10
Work of others	group leader of 8–15 employees in addition to regular duties	50
	group leader of 6–10 employees in addition to own duties	40
	responsible for follow-up assignment and checking work of 3–6 other employees	30
	responsible for instructing new or inexperienced employees in own work or other functions as may be specified; may also be required to follow up or check work of 1 or 2 others	20

* In the servicing of machines, handling time requires only part of cycle time.

TABLE 1 (*contd.*)

Basis of Point Rating

Factor	Degree	Point Rating
Work of others (contd.)	no responsibility except to pass on to others information gained through experience on the job	10
Working conditions	very dirty, hot, or uncomfortable	100
	quite dirty, hot, or uncomfortable	80
	disagreeable	60
	good; slightly dirty or occasional exposure to dust, dirt, heat, fumes, noise, vibration, or wetness	40
	approaching ideal conditions	20
Unavoidable hazards	dangerous work; exposure to serious accidents or occupapational disease	50
	somewhat dangerous work; considerable exposure to lost-time accidents or occupational disease	40
	reasonably safe; some exposure to lost-time accidents or occupational disease	30
	safe; accidents improbable	20
	accident or health hazards negligible	10

TABLE 2

*Summary of Job-Rating Points at Sewage Treatment Plant**

Factors	Job Title			
	Laborer	Operator	Chief Operator	Superintendent
Education	56	84	84	112
Experience	22	88	176	132
Ability	28	56	56	84
Physical demand	60	40	40	40
Mental or visual demand	10	30	30	30
Equipment or process	10	20	20	30
Material	10	20	10	20
Safety of others	20	20	30	30
Work of others	10	10	30	40
Working conditions	40	40	40	40
Unavoidable hazards	30	30	30	30
Total points	296	438	546	588
Average monthly salary	$238	$260	$347	$347

* Plant had an average flow of 0.8 mgd.

Visiting the plants and studying the jobs are necessary in order to determine the job requirements. In addition the job should be discussed with the worker and his superintendent. Descriptions, observations, and discussions give a basis for assigning points to each job for each factor.

Key jobs may be established to further define the factors. These are jobs whose job content properly falls into one of the several degrees of a factor (*1*). Key jobs may then be used as references or "bench marks" for rating other jobs.

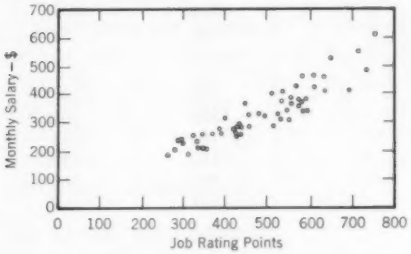

Fig. 1. Scatter Diagram for Twelve Plants

Job points and monthly salaries for three water treatment plants and nine sewage treatment plants and the relative position of each job are shown.

It may be helpful to record the points for each job at a plant on a summary sheet. An example of the points assigned during an actual job evaluation study of a sewage treatment plant is shown in Table 2.

Nine sewage treatment plants of varied types and sizes and three water treatment plants were visited and point-rated for this study. Table 3 is a tabulation of the results. The plants have been identified alphabetically for obvious reasons.

Mathematical Analysis

The mathematical analysis of the data obtained on the study involves several steps. The first step is to plot the job points (X) and the job salaries (Y) on a graph. The total points plotted on the graph make up the plotted on the graph make up a scatter diagram. Figure 1, a scatter diagram based on data from Table 3, shows the relative position of each job within the group.

The best line to represent the scatter diagram shown in Fig. 1 is then constructed. The method that is preferred by many authorities in job evaluation is the least-squares method (*1*). For simplicity, an example will be pre-

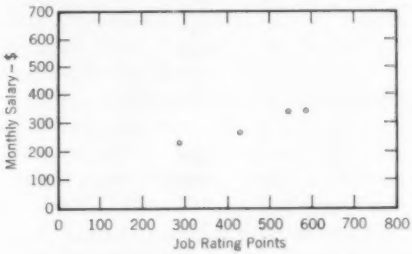

Fig. 2. Scatter Diagram for Plant I

Job points and monthly salaries for Plant I are plotted by the least-squares method, which could also be applied to data from the other eleven plants studied.

sented using the data from Plant I only (see Table 3).

Figure 2 is a scatter diagram for Plant I. These data are arranged in a summation table (Table 4) in four columns: X, Y, XY, and X^2, where X represents job points and Y job salaries. The totals (Σ) obtained in Table 4 are substituted in the following relationships to solve for a and b. N is the number of jobs.

$$\Sigma Y = (\Sigma X)m + Nb \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$\Sigma XY = (\Sigma X^2)m + (\Sigma X)b \quad \ldots\ldots\ldots\ldots \quad (2)$$

Thus, after substitution, Eq 1 and 2 become

$$1{,}192 = 1{,}868m + 4b \quad \ldots\ldots (3)$$

$$577{,}826 = 923{,}320m + 1{,}868b \quad \ldots\ldots (4)$$

Eq 3 is multiplied by $1{,}868 \div 4$, or 467,

$$556{,}664 = 872{,}356m + 1{,}868b \quad \ldots\ldots (5)$$

Eq 5 is then subtracted from Eq 4, with the result:

$$21{,}162 = 50{,}964m$$

or

$$m = 0.415.$$

Substituting m in Eq 3 yields

$$1{,}192 = 0.415(1{,}868) + 4b$$

whence

$$4b = 1{,}192 - 776 = 416$$

and

$$b = 104.$$

TABLE 3

Comparison of Total Job-Rating Points and Monthly Salaries

Plant	Points	Salary $	Plant	Points	Salary $
A	334	290	G	334	230
	448	323		428	282
	552	368			
	510	410			
	604	475	H	308	192
				346	208
				384	258
B	260	195		456	292
	424	282		570	362
	512	292		628	467
	550	314			
			I	296	238
C	278	208		438	287
	438	298		546	347
	578	477		588	347
	648	540			
			J	528	383
D	338	217		458	333
	424	260		578	383
	438	260		296	243
	532	314			
	570	390	K	318	254
				416	279
E	356	210		488	329
	386	288		522	340
	478	340		580	394
	634	417		734	498
	534	417			
	690	417			
	760	622	L	280	248
				368	260
				556	398
F	346	260		448	372
	578	350		610	431
				712	559

From the values calculated for m and b, the next step is to solve for two sets of values of X and Y in the relation:

$$Y = mX + b.$$

Thus, for $m = 0.415$ and $b = 104$,

$$Y = 0.415X + 104.$$

Let $X = 200$; then

$$Y = 0.415(200) + 104 = 83 + 104 = 187.$$

Let $X = 800$; then

$$Y = 0.415(800) + 104 = 332 + 104 = 436.$$

Thus, for $X = 200$, $Y = 187$; and, for $X = 800$, $Y = 436$.

The values for X and Y are plotted on the scatter diagram and the two points are connected. This is the least-squares line for Plant I (Fig. 3). In a like manner, least-squares lines may be calculated for each plant and for all the plants combined (Fig. 4).

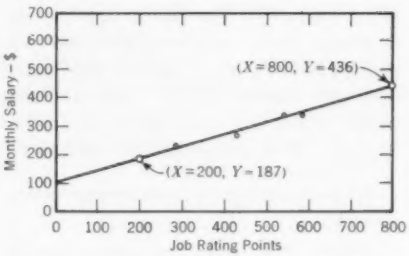

Fig. 3. Least-Squares Lines for Plant I

The least-squares line for Plant I was found by plotting values for X *and* Y *on the scatter diagram and connecting the two points.*

Job Levels and Salaries

The next step in the study was to determine the number of job levels necessary and to calculate the job rating points for each level. During the study it was noticed that six salary ranges, or levels, were the maximum encountered at any one plant. The lowest job rating was 260 points and the highest 760 points. It was reasoned, therefore, that the range of points for the six job levels could be from 260 to 800 points, or 90 points per job level. These job levels are shown in Fig. 5.

TABLE 4

Summation Table for Least-Squares Method

X	Y	XY	X^2
296	238	70,448	87,616
438	260	113,880	191,844
546	347	189,462	298,116
588	347	204,036	345,744
Total (Σ) 1,868	1,192	577,826	923,320

Salary ranges should be determined in a manner that will benefit all job levels equally. This involves considerable experimenting with variations in the number of labor grades, their point values, and the relative position of limit and least-squares lines. Based on six job levels, each with a 90-point range, it was decided that plus or minus 20 per cent would provide adequate salary ranges and overlap between job levels. Figure 6 shows the construction of the limit lines and the resulting salary ranges superimposed on the scatter diagram (Fig. 1).

Analyzing the comparison of the scatter diagram and the job levels with the corresponding salary ranges indicates two discrepancies: points below the salary ranges and points above the salary ranges.

The action to be taken in the first case would be to raise the salary of each job that is below so that it will fall within the corresponding range.

In the second case no action could be taken. In no case would a salary be lowered as a result of a job evalu-

ation study. If the points are left untouched their relative position will change as a result of overall pay raises due to merit raises, cost-of-living raises, changing conditions, and other factors. If it were feasible, additional

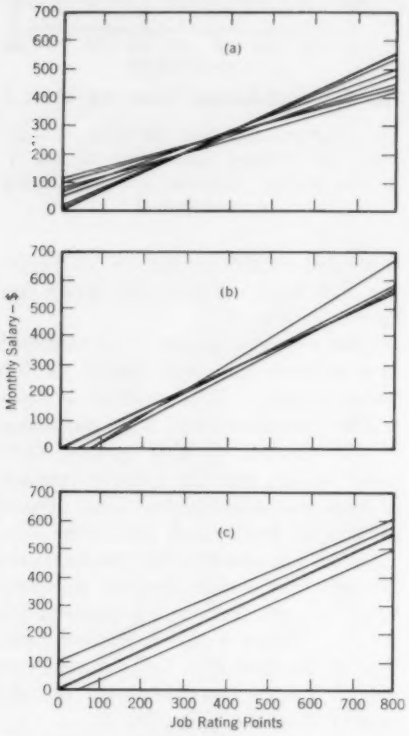

Fig. 4. Least-Squares Lines for All Plants and for Individual Plants

The heavy line in each group is the least-square line for all twelve plants. Fig. 4a also shows lines for six individual plants; Fig. 4b and 4c show lines for three other plants.

responsibility or demands of effort could be assigned to those jobs which are above the salary range of any job level. This would result in more points for the jobs and the statistical effect would be to move them into a higher salary range.

Recommendations

The work involved in conducting job evaluation studies should be performed by a qualified committee in order to achieve consistent and valid results,

TABLE 5

Possible Job Titles, Job Levels, and Salaries for Treatment Plant Employees

Plant	Job Title	Job Level	Monthly Salary $
1	Laborer	I	182–246
	Operator	II	235–318
	Chief operator	III	288–390
2	Laborer	I	182–246
	Operator	II	235–318
	Chief operator	III	288–390
	Superintendent	IV	341–462
3	Laborer	I	182–246
	Assistant operator	II	235–318
	Operator	III	288–390
	Operator-chemist	III	288–390
	Maintenance chief	IV	341–462
	Chief operator	IV	341–462
	Superintendent	V	394–534
4	Laborer	I	182–246
	Sludge tank operator	II	235–318
	Plant operator	III	288–390
	Chemist	IV	341–462
	Maintenance chief	V	394–534
	Chief operator	V	394–534
	Superintendent	VI	448–606

which would be required in a statewide study. The committee should be representative, with perhaps an operator, a superintendent, a member of the state board of health, and possibly a member of a college faculty. The study described in this article was conducted

by an individual, and, therefore, the results are intended to be used only as a guide in conducting a job evaluation study.

The committee should decide on the factors to be considered in rating a job, the definition of each factor, and the weight or value to be assigned to each.

The studies, themselves, should be conducted by the committee. The ultimate goal should be to rate all the jobs in every plant. Of course, in the beginning this would not be feasible, but a sampling of plants from each part of the state would be temporarily satisfactory.

The results from a statewide study should be analyzed to determine if certain plants should be considered in groups in order to establish job levels for a particular area. If necessary, the state might be divided into districts on the basis of local wage scales. Otherwise the state could be considered as one unit and a uniform set of job levels and salary ranges for the unit could be established.

It may be feasible to establish a table which will give the job level and salary range for a specific job at a treatment plant, depending on the plant's size and type. This could be accomplished by using the point ratings arrived at by a job evaluation study. For example, it was observed that the total job rating for an operator at a high-rate trickling filter plant with a capacity of 0.4 mgd placed him in the second job level, whereas an operator in the same type of plant, but with a capacity of 1.0 mgd, was in the third job level. Based on the results of this study, Table 5 further illustrates examples of this type. The plants are represented by numbers but are of specific types and capacities. Table 5 does not represent all of the plants included in the study, and is intended only to be an example, but it may be used in answering inquiries from communities concerned with problems of wage scales or salary ranges in new or proposed plants.

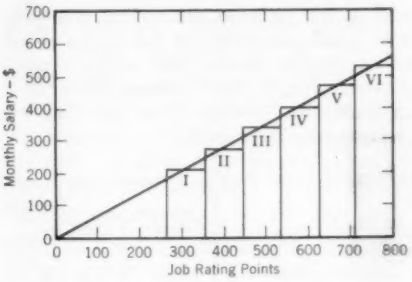

Fig. 5. Job Levels

Six job levels were the maximum encountered at any one plant. On the basis of the job points at these plants, 260–800 job-rating points was adopted as an accurate range.

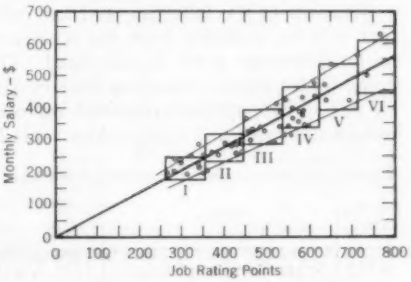

Fig. 6. Salary Ranges and Limit Lines

Salary ranges (Fig. 5) and limit lines are here superimposed on the scatter diagram (Fig. 1) for purposes of comparative analysis.

It is recommended that a permanent committee be maintained for the purpose of reviewing, checking, and comparing job descriptions, point ratings, figure tables, and job levels. Conditions which tend to affect pay are always changing; therefore, this is a never-ending job.

Reference

1. PATTON, J. A. & SMITH, R. S. *Job Evaluation.* Richard D. Irwin, Inc., Homewood, Ill. (1952).

Reprints Available

Reprints of the following articles, published in the JOURNAL during the preceding year, will be available from the Association in small quantities, at the prices noted, until the present stock is exhausted. Order by reprint number and author's name from: Order Dept., American Water Works Assn., Inc., 2 Park Avenue, New York 16, N.Y. **Prepayment required on orders under $2.** (Note: This list does not include standards and similar documents kept permanently in stock.)

Reprint No.	Author	Title	Issue of JOURNAL	No. of Pages	Price per Copy
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R819	CONWAY	Fluoridation Law	Oct 58	7	20¢
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R821	PANEL DISCUSSION	Plastic Pipe	Nov 58	14	25¢
R824	COMMITTEE REPORT	Backflow Preventers	Dec 58	32	45¢

Report of the Committee on Water Works Administration

For the Year Ending December 31, 1958

A report of the activities of the Committee on Water Works Administration for the year ending Dec. 31, 1958, submitted to the AWWA Board of Directors on Jan. 26, 1959, by Wendell R. LaDue, Chairman.

AS outlined in the 1957 AWWA *Directory* (Reference Edition), the present organization of the coordinating Committee on Water Works Administration provides for more than 30 committees and subcommittees, grouped in four classifications, with more than 135 members of the Association participating. The general committee consists of the chairman, the general chairman of the four groups, and the chairmen of the various active subcommittees. Committee work has been broadened by the creation of "task groups," subordinate to standing committees, and by advisors on research and development committees. In general, chairmen of task groups are not members of the Committee on Water Works Administration, as they work within the province of the division under which the group functions. When their work covers activities in several divisions, however, the chairmen become members of the committee. Likewise, advisors to research and development committee advisors are members of the committee. Presently, chairmen of two task groups and advisors on two committees are members of the committee. The present committee personnel are:

Committee on Water Works Administration

W. R. LaDue, *Chairman*

L. S. Finch, *Vice Chairman*	M. P. Hatcher
L. E. Ayres	H. E. Hudson Jr.
J. J. Barr	J. M. Jester
E. L. Bean	A. P. Kuranz
E. S. Cole	R. J. McLeod
John G. Copley	R. S. Millar
G. H. Dyer	J. H. Murdoch Jr.
R. J. Faust	L. N. Thompson
	A. A. Ulrich

W. V. Weir

Inactive Subcommittees

The following subcommittees are now inactive or have not been activated:

4110 M—Constitutional and Statutory Aspects of Municipal Water Works Organization

4150 M—Taxation and Revenue Allocation (task group active)

4210 M—Public Relations (now Committee on Water Utility Advancement *)

4220 M—Management Relations

4310 M—Construction Equipment and Material Contracts

4320 M—Valuation and Depreciation

4330 M—Cost Trends

* See report beginning on p. 543.

4410—Water Department Reports (advisor retained)

4441 M—Industrial Water Use (chairman appointed)

1958 Conference

At the 1958 Conference numerous principal topics stemming from the committee's activities, either directly or indirectly, provided subject material for the various sessions. Attendance was good and member interest was unusually high. In fact, the open sessions of the Committee on Water Works Administration attracted one of the highest attendances of the Conference.

Subcommittee Activities

The continuing and growing interest in and importance of the diversified phases of water works management and administration are evidenced by the steady flow of inquiries into AWWA headquarters and to several committees regarding activities and findings. Increasing studied activity is maintained in present fields of the committee's work and expansion is made into other fields as the Association's program, personnel, and budget will permit, and as the membership requires. The present-day problems of administration are increasing in complexity and importance.

Following is a brief summary of the activities of the several subcommittees during the year 1958, as submitted by the committee chairmen:

4120 M—Radio and Mobile Communication Facilities for Water Works. The committee's activity this year has been in support of work handled through AWWA headquarters. Early in the year questionnaires were mailed from the Association's office relative to the type and use of short-wave radio equipment in the water utility field. These are now being analyzed, processed, and tabulated. It is expected that a report will be available early in 1959 and that a committee meeting will be held at the 1959 Conference to discuss the committee's expanded activities, especially in the field of creating more interest in the subject.

4121 J—National Committee for Utilities Radio. Liaison was maintained with the legal representative of NCUR in Washington. Chairman John M. Jester attended the national meeting of NCUR in Boston in June. It is proposed that the committee expend some of its efforts in a membership drive to bring into AWWA those whose interests lie in the field of communication and to formulate means to maintain the interest of such new members.

The 1955 comprehensive AWWA survey of the use of mobile radio facilities for water utilities showed that 429 utilities were using mobile radio equipment and that 467 potential users servicing an estimated population in excess of 11,500,000, are yet to file for such licenses. It is believed that the use of radio facilities by water utilities is a must for modern efficient operation, not only in emergencies, but in everyday operations.

4130—Water Used in Air Conditioning and Other Refrigeration. The committee completed its survey of ordinances and regulations affecting use of water in air conditioning and in refrigeration. A report of this survey was published in the January 1958 issue of the JOURNAL.

The trends outlined in that report are continuing with no new developments evident at this time.

4140 M—Water Use in Fire Prevention and Protection. This committee is at present functioning on a standby

basis to observe the effects of the National Board of Fire Underwriters' revised rules and regulations. The committee urges that members of the Association review their own situations in the light of the changes. It is further suggested that members give careful attention to new rating surveys.

4150 M—Taxation and Revenue Allocation. Although this committee is not yet active, AWWA has had occasion to present to governmental highway agencies the water utility viewpoint on the important subject of acceptance and allocation of costs and payment of charges due to relocation of facilities proposed by highway authorities. This problem remains constantly before utility managers, as an accelerated program of superhighways and turnpikes develops and continues to expand, encouraged by current federal highway legislation and its recommended implementation. Many states have passed legislation indicating opposite and varying viewpoints on this important subject.

Evidence is present in some areas that aid has been given by a direct monetary means, by inclusion in the contract of a portion of the changes to be made, or by the furnishing of both labor and material as part of the highway construction contract. Each water utility manager should maintain constant vigilance of local, state, and national developments.

4160 J—Joint Committee for Advancement of Sanitary Engineering and *4161 J—American Sanitary Engineering Intersociety Board.* Reference is made to these committees simply to inform the membership of the formation of the American Academy of Sanitary Engineers, the result of the work of these two groups. About a thousand sanitary engineers are now recognized by this board as proficient in the practice of sanitary engineering, thus giving recognition to the profession so closely allied to water utility operations.

[Committee 4160 J was discontinued in November 1958, when AWWA, FSIWA, and ASCE withdrew sponsorship. Since then, ASEIB has taken over the activities of the joint committee.]

4230 M—Compensation of Water Works Personnel. Since AWWA headquarters evaluated the *Survey of Employment Conditions* in 1954, the work of this committee has been relatively light. It is now being stepped up. The replies received from a recent questionnaire on compensation of water utility managers will be tabulated, in preparation for a report at the 1959 Conference. A questionnaire on the fringe benefits of water utility personnel is in preparation. The activities of this committee are of direct personal benefit to the membership.

4240 M—Pension and Retirement Plans. A final report based on a questionnaire sent to water utility managers is nearly ready for submission to the committee members.

Pressure continues to place state pension systems in virtual competition with the federal Social Security act. Changing national attitudes toward all types of pension systems will affect the water industry and are receiving constant attention by this group.

4250 M—Safety Practices. The year 1958 was a very productive year in safety. A total of 528 Section Safety awards was issued—436 Awards of Merit, 69 Awards of Progress, and 33 Awards of Honor. Considering the United States alone and eliminating two sections which did not supply sufficient information, the injury frequency rate for 461 utilities was a low 10.7.

The man-hours of exposure for this group totaled 40,767,208, and there were 435 lost-time injuries. All but the Alabama-Mississippi, Cuban, Intermountain, Montana, and Ohio sections issued safety awards. The Alabama-Mississippi, Intermountain, Montana, and Ohio sections are prepared to issue awards during 1959.

The 1954 US Bureau of Labor Statistics survey, which covered 3,121 utilities of the industry, found an injury frequency rate of 22.2. A comparison between these two reports shows that where utilities adopt and promote a safety program, much good results, the frequency rate having dropped 52 per cent. This is a remarkable showing, of which the whole industry can be proud. The forms for reporting 1958 safety results to section safety committee chairmen have been distributed and the work toward establishing new award winners is going forward rapidly.

At the 1958 Conference the first two Wendell R. LaDue Safety Awards were issued. In Class Size 2, employing 10–100 people, the award was won by the Duluth Water Division. In Class Size 3, employing more than 100 people, the award was won by the East Bay Municipal Utilities District. Both produced enviable records. For 1958 it is hoped that awards in all three class sizes may be issued.

The safety manual has continued to be a best seller of the Association. It appears that, at last, the water industry has become safety conscious.

4260 M—Education. At the 1957 Conference the Board of Directors approved the preparation of four in-service training manuals, as follows: [1] Development of Water Supply, [2] Treatment of Water, [3] Distribution of Water, and [4] Water Utility Management. The committee activity is starting to bear fruit. At the present time the manual for water works managers, comprising 192 pages, is in galley form and is being reviewed by committee members, anticipating that it will be available about April 1959. It should be useful as a text for in-service training courses and equally useful for independent study. Work on the text of the other manuals is well along.

4340 M—Water Main Extension Policy. A summary was prepared as of March 1958 reviewing the work done by this committee to that date and setting out the areas that needed further attention. Since that time members of the committee have been urged to review that study and to offer suggestions as to what further work the committee should do and when it should do it. There has been much exchange of correspondence on these points. It is contemplated now that the committee will have a complete report ready for final consideration at a meeting that it will hold at the 1959 Conference.

There have been no unusual developments that have come to the committee's attention in the last year. A study of the whole problem seems to indicate that practices of individual utilities tend to vary over a rather wide range, and there seems to be a real need for the greater uniformity of practices that will come from a better understanding of matters affecting water main extensions.

4420 M—Water Rates. The committee is still on a standby basis. Water rates under changing economic conditions require constant reevaluation. The ever-increasing demand for water, especially for air conditioning, and for lawn sprinkling, will merit

close attention and study. The cooperation of Committee 4430 M (Water Use) and this committee is essential for a realistic answer to the overall problem. The activity of this committee in the immediate future may well depend upon the information presented at the 1959 Conference by the water use committee.

4430 M—Joint Administration of Water and Sewer Facilities. With the general acceptance of the sewerage service charge and its almost universal collection by the water utility, the trend toward joint administration is expanding, with attendant problems. Preliminary reports of the committee's activities were made at the 1957 and 1958 conferences. The draft of the final report has been completed.

4440 M—Water Use and *4442 M—Residential Water Use.* Data are being gathered on peak demands from cities throughout the United States. These cover relationships of maximum-day to average-day use and relationship of peak hours to maximum days. Particular attention is being paid to gathering information that will yield light on trends in these relationships. Wherever possible, information is being obtained on selected, purely residential areas.

Data have been gathered that will enable a further progress report of the committee at the 1959 Conference on trends in peak demands due to lawn-sprinkling, and possibly air-conditioning, requirements.

4441 M—Industrial Water Use. The activation of the committee may be desirable, to deal with this phase of the problem of water use investigation.

4450 D—Revenue-Producing Water. The committee works in the field of interest of the Distribution Division, which is giving valuable assistance and impetus. Since the presentation of the committee report at the 1957 Conference, the committee has been inactive, having completed its assignment, but will remain in active status as long as desired.

Research and Development Groups

2210 M—Job Classification. This is a task group in the province of the Management Division. It is helpful to Committee 4230 M (Compensation of Water Works Personnel). The chiefs of the Occupational Analysis Branch and the Job Classification Section of the Bureau of Employment in Washington, D. C., have been most cooperative in the work of processing the job titles and descriptions submitted. The Department of Labor has completed about 100 job descriptions at this time. Very helpful cooperation was secured during interviews with personnel of the District of Columbia water department and the Washington Suburban Sanitary Commission. When data from the latter are received, they will be reviewed by the task group.

2220 M—Review and Redevelopment of a Rating Scale for Water Works. The chairman of the task group and many of its members have spoken before sections of the Association and before other interested water utility groups upon the value of the work of this committee. A great deal of work is in progress by the six subgroups, employing many members of the Association. Studies are being made looking toward the combining of the group's separate standards into an overall numerical rating scheme.

2230 M—Committee to Cooperate with NARUC Committee on Revision of System of Accounts for Water Utilities. This committee worked earnestly and very hard for more than 4

years in an attempt to bring the system of accounts promulgated by NARUC into realistic relationship to the construction and operating practices of water utilities. Although these rules are mandatory only upon the operators of privately owned utilities, the classification of accounts is extensively used in publicly owned systems. A currently active problem is the system of accounting for funds used in cleaning, lining, and rehabilitation of old mains.

Encouraging avenues of agreement present themselves from time to time, so that in the end many favorable changes may be accepted.

2240 M—Committee to Cooperate With NARUC Committee on Proposed Rules and Regulations Governing Water Service. The current work of the committee is completed, except to be on the lookout for possible new rules. Therefore, it is believed that the committee should be kept active so that it may be helpful in keeping members of the Association informed of developments.

Recommendations

The attention of the Board is directed to necessary enlarging of the activities of the Committee on Water Works Administration from time to time along current lines. There are numerous projects of the committtee which cannot be handled efficiently strictly on a member-committee basis. They involve a large amount of research and can best be handled as staff projects. The Association's budget can be supplemented by outside funds, especially when a project involves items in which manufacturers or industries are vitally concerned.

Such subcommittee activities which might be considered as projects requiring staff aid are:

4110 M—Constitutional and Statutory Aspects of Municipal Water Works Organization

4150 M—Taxation and Revenue Allocation (now studying highway changes)

4230 M—Compensation of Water Works Employees (now under way)

It is the studied aim of the Committee on Water Works Administration to proceed deliberately, acting upon and anticipating obvious member demands and expanding interests, in a long-time policy of continuing and current activities; to maintain close cooperation with the Committee on Water Works Practice and with the Technical Program Committee; and to encourage obvious member participation as task groups of the divisions. Appreciation is hereby extended to AWWA personnel and to all committee chairmen and committeemen for the many unselfish services rendered. The ever-valued counsel, consideration, and guidance of the members of the Board of Directors are gratefully acknowledged.

Report of the Committee on Water Works Practice

—For the Year Ending December 31, 1958—

A report of the activities of the Committee on Water Works Practice for the year ending Dec. 31, 1958, submitted to the AWWA Board of Directors on Jan. 26, 1959, by Louis R. Howson, Chairman.

ACTIVITIES under the jurisdiction of the Water Works Practice Committee have made substantial progress during the year 1958. The willingness of Association members to serve on standards committees has continued unabated. Several important documents have been brought to a conclusion during the year.

Probably the most outstanding accomplishment was the development of a standard for submersible pumps. This work has been carried on by a committee operating under the jurisdiction of the American Standards Assn., under the chairmanship of Marvin Owen and Perry H. Brown, both of Los Angeles. The work has been in progress since 1949, the first assignment of the committee being the development of a standard on deep well vertical turbine pumps. The committee has now completed its development of the standards for submersible pumps and has also revised certain details of the current deep well pump standard (ASA B58.1; AWWA A101).

The revision of the Standard for Deep Wells (AWWA A100) has been published and is now jointly sponsored by AWWA and the National Water Well Assn.

Chemical Standards

James Kerslake, who for several years has acted as adviser in the development of standards for water treatment chemicals, has resigned because of change of location of his business activities. He is now operating a water treatment plant in South America. His successor is James Vaughn of the Chicago Water Dept. The work done by Kerslake over the years has been very commendable. He will be seriously missed in the water treatment field in the United States.

Standards for liquid chlorine (AWWA B301) and copper sulfate (AWWA B602) were published during the year. No suggestions for change have been filed for either standard. They are recommended to be advanced to Standard status.

Fluoride standards. The three standards for fluoride-containing chemicals (B701, B702, and B703) have been referred to a special committee, operating under the chairmanship of Oscar Gullans, for the purpose of making certain minor revisions in the text. [Revisions for B701 and B703 have been completed; revisions for B702 will be completed soon.]

Sodium aluminate. A new standard for sodium aluminate has been cleared by the Water Works Practice Committee and has now been sent to the members of the Board of Directors for their approval at the January 1959 meeting. [The standard was approved as Tentative.]

Soda ash. A revision of the existing standard (B201) has passed through the approval channels and is to be considered by the Board during the January 1959 meeting. [The revision was accepted.]

Liquid alum. Standard B403 for aluminum sulfate has been amended to include liquid alum. [The amendments to the Standard were published in the February 1959 issue of the JOURNAL.]

Ferric sulfate. E. L. Bean of Philadelphia has taken over this assignment from E. B. Evans of Dayton and is presently engaged in the preparation of a proposed standard.

Ion exchanger test procedures. A task group has been established under the chairmanship of Eugene Bowers of the Metropolitan Water District of Southern California to revise the existing document. The current text, B250, was made Standard in 1951. A great deal of progress has been made in this field since that time. Chairman Bowers has a competent group working with him: T. C Hoppe, of Black and Veatch; Sidney Sussman, of the Water Service Laboratories, New York; H. Gladys Swope of Argonne National Laboratory; and an advisory group of seven producers.

Standard Methods for the Examination of Water, Sewage, and Industrial Wastes. This continuing activity is under the sponsorship of AWWA, APHA, and FSIWA. Michael Taras of the Detroit Water Dept. represents AWWA on the three-man editorial board. Taras has handled his assignment with extraordinary competency and diligence.

At a meeting of the Joint Editorial Board on Sep. 5, 1958, a review committee was set up. The following were appointed as AWWA representatives: Harry P. Kramer of the Taft Engineering Center, Cincinnati; T. E. Larson, Urbana, Ill.; and R. L. Derby, Los Angeles.

Drinking water standard. The US Public Health Service has appointed a committee to consider the revision of its drinking water standard. Oscar Gullans has been appointed by USPHS to represent AWWA.

Distribution System Standards

Cast-iron pipe and fittings. The committee was reorganized at a meeting called by Thomas H. Wiggin, the chairman, on Jan. 29, 1958. By-laws were adopted and five subcommittees were developed, on: [1] pipe, [2] joints for pipe and fittings, [3] fittings, [4] coatings and linings, and [5] editorial matters. Additional committee meetings were held in April 1958, at Dallas, and in June and November, at New York. The subcommittees are now fully developed and staffed, and meetings have been scheduled.

Although no progress in the revision of the old standards or the development of new standards can be reported at this time, it is important to note that subcommittee activity is well advanced.

Steel water pipe. AWWA C208, the Standard for Dimensions for Steel Water Pipe Fittings, published in July 1956, should be advanced to Standard. [The Board approved this recommendation.]

A revision of the Standard for Cement-Mortar Protective Coatings for Steel Water Pipe (AWWA C205) is in process. The members of the committee are: D. A. Stromsoe, J. W. Trahern, T. H. Wiggin, and H. A. Price Sr.

At the request of the California Section, the chairman of the Water Works Practice Committee approved the Section's establishing a task group to study the problem of electrical ground-

ing to pipelines. The members of the committee are: L. E. Tabor, F. O. Waters, L. E. Magoffin, H. E. Wilson, Harry J. Keeling, Carl Lauenstein, and Robert C. Kennedy. L. E. Tabor's competency for standardization activity is recognized by all persons who know him, and it can be anticipated that the results of this group's activities will add substantially to the fund of knowledge available to Association members.

Reinforced concrete pipe. No changes are recommended in the status of the three standards for reinforced concrete pipe. AWWA C301, for Reinforced Concrete Water Pipe—Steel Cylinder Type, Prestressed, was advanced to Standard in January 1958. Ernest Whitlock, chairman of the committee, reports progress in the development of a manual for installation of reinforced concrete pipe.

Asbestos-cement pipe. Standard C400, issued in 1953, has remained Tentative during the intervening years. During 1958, a committee was appointed to work, under the chairmanship of Roy Ritter of Baltimore. The preliminary meeting of some of the members of the committee with representatives of the principal manufacturers of asbestos-cement pipe was held on Jan. 14, 1959. A general preview was made of the problems before the committee, and the revised text will be made available to the members of the Board before or at the time of the 1959 Conference. The members of the committee working with Ritter are: E. H. Aldrich, F. Gordon Denson, Claud R. Erickson, Justin E Farrell, W. R. Gelston, J. Elliott Hale, X. D. Murden, A. J. Maahs, and Charles R. Meek.

Valves, sluice gates, and hydrants. The current gate valve standard (AWWA C500) has been for several years in the hands of a committee, under the chairmanship of David Auld, for revision. The revised text is to be submitted to the Board for approval. No major change has been written into the text, but substantial improvement has been made in clarifying obscure paragraphs in the existing standard. [The changes were approved, and the standard remains Tentative.]

No revisions are presented for the standards for butterfly valves (AWWA C504 and C505).

It is recommended that committees be appointed to revise the Tentative AWWA Standard for Sluice Gates (AWWA C501). [The recommendation was approved.]

The present standard covering dry-barrel hydrants (AWWA C502) should be reviewed and revised. During 1958 the standard for wet-barrel hydrants (AWWA C503) was approved and published. It will be presented for advancement to Standard status at the July 1959 Board meeting.

Pipelaying. No revisions are under consideration for standards AWWA C600 or C601 (installation of cast-iron water mains and disinfecting water mains), nor is the Standard for Cement-Mortar Lining of Water Pipelines in Place (AWWA C602) being revised.

Meters. The committee on meter standards has under consideration the revision of several of the meter documents. Revisions will be presented for consideration prior to July 1959. [The Board approved the pending meter manual with an expression of appreciation to the committee.]

Storage. A revision to the standard for steel water tanks has been prepared and is recommended for adoption by the Board. [The revision was adopted.]

Service line materials. J. L. Bradbury, who represents the Association

on ASA Committee A112 (Dimensional Standardization of Plumbing Equipment), has recommended certain revisions in the text of the standard on service line materials (AWWA C800). These recommendations are based upon the fact that the commercial standard for lead pipe has been changed since the AWWA document referred to it. The revision needs to be made to bring the AWWA document into line with the federal standard.

Division Task Groups

Water Resources Division. Task group activities on weather control and on salinity reduction are not active.

The task group on Ground Water Recharge made a report in 1958 and has scheduled a report to be presented in 1960.

The task group on underground waste disposal has been reorganized under the chairmanship of Lynn Miller and has scheduled a report for the 1959 convention. The other members of the task group are: H. J. Ongerth, W. N. Gahr, Ernest F. Gloyna, C. E. Carl, Harvey Wilke, Rupert Kountz, G. W. Moore, George Glover, Sidney Wells, A. G. Fiedler, and J. G. Ferris.

Water Purification Division. For a number of years, the Water Purification Division has listed the Task Group on Survey of State Regulations on Water Treatment Plant Design. The committee is inactive, but it is recommended that the work be activated. [The recommendation was approved.]

The task group on synthetic detergents is very active, under the leadership of James Vaughn. A report from his group was published in the October 1958 JOURNAL. Synthetic detergents are a major problem in the field of water pollution and water treatment. Consideration of the situation deriving from the use of synthetic detergents is not confined to the United States, but also is a very serious problem in the British Isles and various places in western Europe. The producers of these materials are giving consideration to changes in the formulas, which would produce a waste product less resistant to purification, and at the same time, water treatment agencies and sewage treatment agencies are actively concerned with the elimination of the end effects of synthetic detergents.

The task group on biological infestation of purified water has been relatively inactive during the past year. The former chairman, C. E. Renn, resigned, and M. P. Crabill has been appointed as chairman. William M. Ingram and Robert J. Becker were added to the task group.

Manganese deposition in pipelines. Task Group 2680 P, on manganese deposition, headed by A. E. Griffin, is developing a document on the subject of manganese. The document will include the following topics: distribution, occurrence, significance, removal methods, methods of determination, tolerance limits, research, and conclusions. Several parts of the document are completed and will be presented at the 1959 conference. Completion of the entire document is scheduled for 1960, when some of the final material may be presented at the annual conference in Miami Beach. This task group has outlined an ambitious program and is well on its way toward completing it.

Joint Committees

Water filtration. The joint committee on revision of ASCE Manual No. 19 (filtration of water) did not make the progress during 1958 which

should have been achieved. Discussions are presently being carried on looking toward the dissolution of the joint committee. It has been recommended that AWWA take over the project in the form of a revision of the Association's *Water Quality and Treatment*. Decision is awaited on the part of ASCE sanitary engineering division representatives.

Because a revised edition of *Water Quality and Treatment* is planned for 1960 publication even if there is no ASCE action, it is recommended that the committee for its revision be activated. [The Board approved.]

International standards. S. Logan Kerr, who is active in the affairs of the American Standards Assn. and the International Standards Organization, has recommended strongly that AWWA consider participation in activities of the international group. [The Board agreed to consider Kerr's recommendations.]

Plastic pipe and fittings. AWWA is represented on two ASA Committees and one ASTM Committee dealing with plastic pipe and fittings. These committees are:

1. ASA Committee B16.12—Nonmetallic (Plastic) Pipe Fittings
2. ASA Committee B72—Plastic Pipe
3. ASTM Committee D20 ABS [Acrylonitrile-butadiene-styrene] Pipe and Fittings.

To elaborate still further, ASA Committee B16.12 has proposed standards well advanced, as follows: [1] Plastic Insert Fittings for Flexible Polyethylene Pipe; [2] Unplasticized Polyvinyl Chloride Screwed Fittings; and [3] Unplasticized PVC [Polyvinyl Chloride] Socket-Type IPS [Iron Pipe Size] Pipe Fittings.

ASA Committee B72 has the following proposed standards well advanced: [1] Rigid Unplasticized PVC pipe; [2] Flexible Polyethylene Pipe; and [3] Rigid ABS-IPS Pipe.

ASTM Committee D20 has the following proposed standard well advanced: Performance Specification for ABS-IPS Pipe.

One action of Committee B72, of special interest to AWWA, is that the committee voted not to consider SWP (solvent welded pipe) pipe sizes in preparing standards. The SWP sizes did not correspond to IPS or the copper tube sizes, so would have resulted only in additional confusion and expense.

As all of the above mentioned standards are well advanced and decisions by ballot are required at each step of advancement, it was considered desirable to activate the AWWA committee on plastic pipe and fittings (approved by the Board in January 1957) at once to share the responsibility of the AWWA representative for decisions.

Joint Committee on Backflow Preventers. This joint committee, sponsored by the AWWA and CSSE, was established in April 1953. It worked unceasingly on the development of a report about the use of backflow preventers of the reduced-pressure principle. The scope of the committee was later expanded to include all types of cross-connection devices.

The committee report, published in the December 1958 JOURNAL, provides an assembly of pertinent information on backflow preventers and states certain findings concerning the use of this type of equipment. Its significant contribution is that it emphasizes the need for continued study and investigation and specifically designates seven areas for exploration by a future committee.

[See December 1958 JOURNAL, p. 1617.]

It is anticipated that a new joint committee will be established and given the seven responsibilities. The personnel of this committee has not been established primarily because CSSE has not proposed any names. As far as AWWA is concerned, it should be reported that at least six or eight members are quite anxious to be appointed to the committee. Thus, the size of the committee may be increased. Its development should not be long delayed.

AWWA Spillway Committee. The present AWWA committee was established by an invitation from AWWA dated Dec. 22, 1958, and is composed of the following men: Thomas H. Wiggin (chairman), Thomas R. Camp, Ralph D. Goodrich, Karl R. Kennison, Earl F. O'Brien, Roy E. Oltman, C. J. Posey, and Harold A. Vicker. The committee personnel were carefully chosen and have wide experience in the design and operation of dams used principally for water supply.

Thomas H. Wiggin, chairman of the committee, in a recent letter, assigned certain portions of the committee's responsibilities to each of the members, with the suggestion that they fulfill these obligations prior to the first formal meeting of the committee. It is hoped that the new committee will reach a satisfactory solution to the problem.

The original joint committee was developed in 1954 under the sponsorship of AWWA and ASCE. The joint committee held two meetings and then ceased to function because of parallel activity established in the hydraulic division of ASCE. Because the two committees could not get together on a common agenda, AWWA and ASCE formally dissolved the joint committee.

It is planned and anticipated that a final report of the AWWA committee will be available within 2 years.

Joint Committee on Training and Certification of Water Works Operators (AWWA-CSSE). Organization of this committee was approved by the Board at the 1958 Conference. After a long delay, CSSE appointed its personnel, but no further activity has ensued.

American Standards Association Activities. Committee B76 of ASA is developing standards for industrial cooling towers. Elmer Knoedler represents AWWA on the Committee and is actively engaged in the operations of the subcommittee on water treating. The scope of the subcommittee is as follows:

> Using available practical experience . . . or theoretical considerations, determine the compatibility of the various chemicals found in cooling water with the materials of construction used in, on, or adjacent to cooling towers. The chemicals to be considered will either be present as naturally occurring impurities, as chemical additives, or as process or atmospheric inleakage. If applicable, the effects of temperature and chemical concentration will be included. Each chemical and temperature range will be grouped with each material of construction as either good, fair, unsuitable . . . depending on conditions, or unknown because of insufficient information or usage. Those combinations designated as good will be the ones recommended as standard materials of construction by the ASA Committee B76.

For a number of years, AWWA has been represented on ASA committees B26 (fire-hose coupling screw threads) and B33 (other coupling screw threads). A policy decision has been made within ASA to consolidate these two projects. Some correspondence has ensued since that decision was

made, but no activity has been initiated by ASA. W. E. MacDonald, who represented AWWA for a number of years on the hose coupling screw thread committee, has resigned as AWWA representative. One or two competent individuals should be designated to represent AWWA when the new committee is activated.

Research Projects

Cadmium and chromium toxicity and solubility. This study was started in 1954 at Michigan State University, with funds supplied by the National Institutes of Health. The study continues with additional funds from the same source. A summary of the latest findings follows:

1. Five groups of rats were given water containing between 0.1 and 10.0 ppm cadmium for 1 year. No differences between these groups and controls were observed in water intake, food consumption, or body weight, nor were any pathological changes in blood or other tissues noted.

The cadmium content of the liver and kidneys increased in direct proportion to the cadmium intake. Tissue values obtained at the end of 1 year's ingestion were roughly double those obtained at the end of 6 months. Kidneys retained two to three times the amount of cadmium retained by the liver when calculated as micrograms of cadmium per gram of fresh tissue.

A reduction in growth rate, water consumption, and blood hemoglobin was found in rats ingesting 50 ppm cadmium for 3 months. Bleaching of incisors was also observed in these animals.

2. Five groups of rats were given water containing between 0.45 and 11 ppm of chromium as chromate ion for 1 year. No differences were observed between these groups and the controls as to water intake, food consumption, or weight gain; nor did an analysis of blood at monthly intervals or examination of tissues at 6 months or 1 year show any significant differences between any of the groups given chromium and the control group.

Kidneys, livers, and femurs were analyzed for chromium at the end of 6 months, and these plus spleen were analyzed at the end of 1 year. There was an abrupt rise in tissue chromium concentration when rats ingested water having concentrations of more than 5 ppm chromate ion.

Two groups of rats were given water containing 25 ppm chromium as hexavalent and trivalent chromium, respectively, for 1 year. No toxic symptoms were observed in either group. Tissue concentrations of chromium, however, were approximately nine times higher in the group given hexavalent chromium. This suggests that chromate ion is absorbed to a much greater extent than trivalent chromium at this level.

Protective coatings. This study is under the direction of Robert F. McCauley, of Michigan State University. Its objective is to develop an interior coating for pipe in the distribution system by means of water treatment and thus minimize corrosion and maintain carrying capacity. This study is financed with funds from the National Institutes of Health. The study was started in late 1956 and is making good progress.

Coagulation. The study of water coagulation at the University of Florida was started in 1957 and financed by the National Institutes of Health. A. P. Black and A. M. Buswell head the research team. The first objectives of the study are: [1] the standardization

of the jar test, [2] the preparation of a turbidity standard, [3] the consideration of polyelectrolytes and coagulant aids, and [4] the evaluation of the activity of silica sols.

[Reports resulting from this study that have been recently published in the JOURNAL are "Electrophoretic Studies of Water Coagulation" (November 1958) and "Effectiveness of Polyelectrolyte Coagulant Aids in Turbidity Removal" (February 1959).

The USPHS Technical Advisory Committee on Coagulant Aids for Water has listed certain products which may be used for water treatment—in the concentration recommended by the manufacturer—with no adverse physiological effects on consumers. The list of products appears in the February 1959 JOURNAL.]

Evaporation reduction. Reports on the study of evaporation reduction indicate that hexadecanol continues to be favorably considered for the film to be used as an evaporation barrier. The chief problems at present relate to the application and retention of a monomolecular film on the surface of an open body of water. It is hoped that such films will reduce the water loss due to evaporation as much as 40 per cent. The economic aspects of the method are also under consideration.

[M. B. Cunningham is scheduled to report at the 1959 Conference on a study underway at Oklahoma City.]

Manganese. Floyd I. Brownley Jr., of Clemson College, continues to work on this project, but in a decreasing capacity, as he has recently become dean of the School of Chemistry. Although his time for research has been materially reduced, he has promised to give a report on his studies before relinquishing this project.

Impurities in liquid chlorine. This project, started in 1958, is under the direction of M. G. Mellon, professor of analytical chemistry at Purdue University. It is financed with a grant from the National Institutes of Health.

The object of the study is to identify and to determine test methods for the impurities in liquid chlorine. Most, if not all, of the impurities are known, but quantitative test methods are lacking. Until suitable test methods are developed and established, standards for liquid chlorine will remain inadequate.

Effect of treatment methods on carrying capacities of mains. The objective of this research, begun in 1955, is to study the effects of mineral content on the corrosion and tuberculation of cast-iron pipe, with special reference to loss in carrying capacity through tuberculation. The study is supported by a grant of money from the National Institutes of Health and is headed by T. E. Larson.

The latest progress report on the study—"Current Research on Corrosion and Tuberculation of Cast Iron"—was published in the November 1958 JOURNAL.

Copper water service study. Specimens of copper water service tubing from approximately twenty communities in the United States and Canada were collected for study to determine serviceability. The study is being conducted by Water Service Laboratories, Inc., of New York City. It is expected that a report will be available sometime in 1959.

Report on Publications

For the Year Ending December 31, 1958

A report on the publishing activities of the Association for the year ending Dec. 31, 1958, submitted to the AWWA Board of Directors on Jan. 26, 1959, by Eric F. Johnson, Asst. Secretary—Publications.

WILLING WATER was the star of the publications list during 1958 in its shift in July from an 8-page bimonthly to a 12-page monthly and in its subsequent experimentation with new features. The JOURNAL, meanwhile, continued to grow, too, despite a slight setback in number of advertising pages, apparently the result of the economic slowdown in the early part of the year.

Sales of the safety manual, which received strong support by section safety committees, actually increased during 1958, while sales of other publications, as is usual in the year between biennial direct-mail sales efforts, fell off. Three new standards were the only new publications issued, but both the management manual and the steel pipe manual were in galley proof by the end of the year and ready for early 1959 release. Meanwhile, 1959 plans include publication of a meter manual and the preparation for 1960 publication of the eleventh edition of *Standard Methods*, the third edition of *Water Quality and Treatment*, and the new distribution manual in the education series.

1. The Journal

A detailed picture of JOURNAL contents, costs, and income for the past 5 years is presented in Tables 1 and 2.

a. Contents. As indicated in Table 1, not only did the text section of the JOURNAL exceed the 1957 high and the goal of 1,650 pages, but the number of articles included increased by more than 25 per cent. For the most part, this increase in number represents a decrease in size, particularly reflecting the absence of the 144-page survey of operating data. Offsetting the increase in the text section was a decrease in advertising pages, so that the overall size of the JOURNAL was held to its 1957 total.

b. Cost and income. In being 32 pages smaller than expected, the 1958 JOURNAL was also slightly less expensive, despite the 12.7 per cent increase in printing rates that became effective with the December issue. While advertising pages dropped below 1957, advertising income, reflecting the 10 per cent increase in rates that went into effect during the year, pushed ahead to a record $132,000, a figure 5.7 per cent above the 1957 total.

c. The future. With a printing rate increase of almost 13 per cent, as well as further increases in paper and production costs, to face in 1959, the staff expects to offset the rise partially by space economies in the advertising section. Partly through rearrangement and partly through the transfer of such features as "New Members" and "Sec-

tion Meetings" to *Willing Water* it is felt that approximately 100 pages can be saved without cutting the text allotment of 1,650 pages. Thus, on the basis of a 2,976-page JOURNAL in 1959, a budget of $110,000 is indicated. Meanwhile, the brightening economic picture and the effect of bringing all contracts under the new rate for the full year indicate an optimistic estimate of $137,500 for 1959 advertising income.

As indicated last year, the staff has made a report to the AWWA Finance

TABLE 1

Journal Contents, Costs, and Income, 1954–58

Item	1954	1955	1956	1957	1958
Contents					
Text pages	1,366	1,262	1,618	1,646	1,682
P&R pages	1,258	1,282	1,262	1,426	1,390
Total pages	2,624	2,544	2,880	3,072	3,072
Text articles					
Conference papers	24	23	54	28	41
Section papers	67	90	60	83	92
Contributions	36	19	50	33	46
Reports & official documents	18	13	15	17	25
Total articles	145	145	179	161	204
Abstract pages	75	72	55	100	99
*Costs**					
Production	$ 4,598	$ 5,303	$ 8,144	$ 7,505	$ 7,623
Printing	46,182	47,217	55,266	64,238	65,991
Paper	15,207	15,232	19,033	23,284	25,030
Total costs	$65,987	$67,752	$82,443	$95,027	$98,644
Total-cost index†	99.9	102.7	125.2	143.9	149.4
Cost per copy	46.5¢	45.9¢	53.0¢	57.0¢	56.0¢
Cost per 1,000 pages	$ 2.09	$ 2.13	$ 2.17	$ 2.19	$ 2.15
Printing rate index†	101.9	101.9	102.5	108.7	109.9‡
Paper rate index†	102.0	104.1	110.1	118.2	120.4
Income					
Advertising	$100,951	$107,209	$115,816	$124,889	$131,988*
Subscriptions	$ 8,943	$ 9,172	$ 9,879	$ 10,946	$ 11,788
Total pages paid advertising	926	969	987	1,092	1,040
Advertising rate index†	109.4	109.4	117.7	117.7	129.4
Rate per 1,000 circulation	$ 8.70	$ 8.17	$ 8.34	$ 7.94	$ 8.27
Circulation (avg paid per issue)	10,687	11,281	11,844	12,639	13,316
Circulation index†	104.4	110.2	115.6	123.4	130.1

* At variance with audit figures because of different basis.
† 1953 = 100.
‡ The rise over 1957 is due to an increase which went into effect in December 1958. In 1959 the printing rate index will be 122.5, representing a 12.7 per cent increase in the 1957–58 rate.

TABLE 2

Relation of Journal Cost to Advertising Income, 1954–59

Year	Total Cost $	Advertising Income $	Dollar Spread $	Percentage Spread %
1954	65,987	100,951	34,964	53.0
1955	67,752	107,209	39,457	58.2
1956	82,442	115,816	33,374	40.4
1957	95,034	124,889	29,855	31.5
1958	98,644	131,988	33,344	34.0
1959*	110,000	137,500	27,500	25.0

* Budget figures.

Committee on the possibility of readjusting advertising rates so that they approach more nearly the level which a commercial publisher would set for a medium of equivalent value. A great many factors, including such fundamental matters as the Association's objectives, are involved in considering so great a change, and the matter will undoubtedly be weighed together with the general recommendations of the new Committee on AWWA Activities and Objectives before a final decision is made. As the time when a decision can be expected is not now known, recommendations concerning a 1960 advertising rate increase are being deferred. Action on the 1960 rate schedule will, however, have to be taken by July.

2. The Directory

A comparison of the 1958 *Directory* with the two previous Membership List Editions (Table 3) shows two trends —an upward trend in size and overall cost and a downward trend in net cost per copy. Responsible for the upward trend were an 11 per cent increase in membership and a 25 per cent increase in advertising pages, combined with a 15 per cent boost in printing and production prices. And it was the 25 per cent increase in advertising, together with a 10 per cent increase in advertising rates, that resulted in lowering the net cost per copy.

On the basis of the relatively small number of complaints received, it has been concluded that the new system of verifying listings that was introduced with this *Directory* was successful. As its continuing use promises not only an increase in accuracy of listings, but a spreading out of the mounting work required to produce the list, the system has now been put into full effect.

In 1959 the Reference Edition of the *Directory*, including Association information, the consultants directory, and the buyers' guide, is due to appear again. To make this useful book even more valuable to the water works buyer, arrangements are being made to include information on Associate Member branch offices and agents. With this additional feature, a book of at least 224 pages is being planned at a cost estimated to total $9,500. Advertising income is expected to total $10,000, again more than offsetting the direct expenditures for this edition.

3. Standards and Reprints

New standards issued during 1958 include those for wet-barrel hydrants

TABLE 3

Comparative Data on Directory *Membership List Editions, 1954–58*

Item	1954	1956	1958
Members included	10,000	11,138	12,332
Total pages	256	272	320
Number of copies printed	12,643	15,047	16,200
Total cost	$9,036	$11,190	$13,724
Cost per 1,000 pages	$2.59	$2.69	$2.61
Cost per copy	71.5¢	74.4¢	84.7¢
Cost per member	90.3¢	$1.00	$1.11
Total pages paid advertising	46	56	70
Advertising income	$4,802	$6,557	$9,186
Net cost per copy	33.5¢	30.8¢	28.0¢

(C503), copper sulfate (B602), and liquid chlorine (B301). All these were published in the JOURNAL and subsequently made available in reprint form. Although income from standards dropped for a second year, this time from $14,400 to $12,500, the indication was that individual sales and use of the standards continued to grow and that it was again a drop in bulk sales of the larger (more expensive) standards that accounted for the fewer dollars.

Reprint sales during the year kept abreast of the $8,600 record of 1957.

4. Willing Water

As was intimated previously, *Willing Water* received considerably more of the staff's attention during 1958 than its total of 108 pages in nine issues might suggest. The shift from a bimonthly 8 pages to a monthly 12 pages in July involved a good bit more than more material.* In place of more-or-less informal arrangements for production, monthly issuance necessitated the establishment of exacting production and mailing schedules, made it desirable to obtain the advantages of second-class mailing privileges, made it feasible to purchase paper and envelopes on a more economical basis, and, in general, meant fitting *Willing Water* in as a "regular" part of the editorial staff workload.

By now the production details of *Willing Water* are essentially established, but what remains to be determined is its proper content. In the issues to date, an effort has been made to shift some of its emphasis from public relations to membership relations. Thus, section meeting reports and new-member listings have been transferred to its pages, and it is hoped that it will eventually provide regular coverage of news of section, as well as Association, activities. Beyond that, as was indicated in recommending the change last year, it is expected that *Willing Water* will become an important organ of the new advancement program. As the Advancement Committee's recommendations had not yet been approved by the end of the year, no definite action along this line was taken in 1958, but a suggested use of *Willing Water* to produce and convey a special 4-page quarterly bulletin to mayors and councils has been worked into the committee's planning.

Although it was originally estimated that a monthly *Willing Water* of 16 pages would probably be required, all issues to date have been held to 12 pages, and, until there is assurance of a backlog of worthwhile material, it is being recommended that the 12-page size be continued. On the basis that

TABLE 4

Publication History of Willing Water

Publication Title	Schedule	No. of Issues	Designation	Dates
Blueprint Now	irregular	8	No. 1–8	Sep. 1944–Nov. 1945
Public Relations at Work	irregular	8	No. 1–8	Oct. 1946–Jul. 1949
Willing Water	irregular	11	No. 9–19	Nov. 1949–Oct. 1952
Willing Water	bimonthly	33	No. 20–52	Feb. 1953–Jun. 1958
Willing Water	monthly	—	Vol. 2–	Jul. 1958–

* A brief history of the development of *Willing Water* and its predecessor publications is presented in Table 4.

this size will be able to accommodate both general Association and advancement program requirements during 1959, a budget of $16,000 has been recommended.

5. Booklets and Public Relations Aids

As will be noted from the summary of sales, cost, and income figures (Table 5), particularly the first two of the three booklets now being offered for sale continue to be both popular and profitable. And, though their sales dropped off somewhat during 1958, it is expected that some special promotion will assure their continuance on the bestseller list. Meanwhile, to reinforce the booklets as public relations tools, the Association last April introduced a film version of *The Story of Water Supply*. And all through the year sales from the catalog of public relations aids were at a record high.

a. The Story of Water Supply. Even though sales of *The Story of Water Supply* suffered a drop of more than 20 per cent, the fact that 187,500 copies were sold during 1958 without any special promotion would seem to indicate that interest in this publication is still alive. During 1959 additional effort will be made to advertise its availability.

b. Your Water Supply. Difficulties in obtaining satisfactory imprinting service in the New York area somewhat hampered sales of *Your Water Supply*. During the year, however, the inventory of 46,000 copies on hand was sold, and an additional 15,000 copies were on order at the end of the year to be supplied from a new printing completed early in January. This booklet, too, is one that remains popular and merits additional promotion from time to time.

c. What Price Water? Although a total of 40,000 copies of *What Price Water?*, using up most of the second 50,000-copy printing, were sold during the year, the record of this booklet, which was introduced in its present form in October 1957, has been disappointing. Designed to attract wide distribution, its sales have continued to be primarily in small lots, presumably for special rather than general distribution. It is encouraging, however, to note that its message has apparently been found useful by utilities in their own advertising and brochures.

d. Sound slide film. Introduced in two-a-day performances at the Annual Conference last April was a 15-min, 35-mm, color, sound slide film version of *The Story of Water Supply*. Suitable for use in schools in conjunction with the booklet and its teaching aids and for showing before civic clubs and home show audiences, the film is the kind of tool that many members have

TABLE 5

Summary Data on Public Relations Booklets Through 1958

Booklet	No. Printed	No. Sold	Inventory	Production & Sales Expense $	Income $	Inventory Value $
Story of Water Supply	1,500,000	1,295,700	204,300	36,122.03	56,487.55	3,697.83
Your Water Supply	920,585	920,485	100	14,950.83	24,057.54	1.30
What Price Water?	100,000	77,200	22,800	2,855.86	2,951.68	389.42

long been requesting. It was finally made possible by the very fine cooperation of Arthur Rankin Jr. Assocs., which agreed to produce the film at no cost to AWWA if the Association provided the script, supplied technical criticism, and then promoted the sale of the film. A sales price of $35 per copy was agreed upon in advance, with the understanding that the full amount would be paid to the producer on the first 200 copies of the film, after which AWWA would share the income.

To date, in addition to its premier presentations, the film has been made available for showing at all section meetings and has been advertised in *Willing Water,* the JOURNAL, and through direct-mail sales sheets. Although its reception has been universally enthusiastic, the enthusiasm has yet to be reflected in action, sales last year totaling only 40 copies. The promotional effort will be continued in 1959, for it is felt that the film provides a needed tool for utility public relations.

e. Other public relations aids. During 1958 the other public relations aids offered by the Association—newspaper mats and electrotypes, posters, postal meter ads, decalcomanias, and novelties—were in greater demand than ever before. Particularly popular was the "Willing Water" service pin, which many utilities awarded to their long-tenure employees in special celebrations. In 1959 it is hoped to make available a new "Willing Water" decal for use on utility trucks and other equipment.

6. Books

The much-mentioned promotion hiatus affected book sales, too, as will be noted in the 1958 review below. (The full financial and sales data on the five titles published by the Association are provided in Table 6.)

TABLE 6

Summary Data on Current AWWA Books and Manuals

Year Published	Book	No. Printed	No. Bound	No. Sold	Inventory		Production & Sales Expense $	Income $	Value of Inventory on Hand $
					Bound	Unbound			
1938	*Manual of Accounting*	1,898	1,898	1,786	112		3,460.49	6,235.70	166.88
1946	*Survival and Retirement*	3,006	2,509	2,247	262	490	5,181.50	6,377.14	922.16
1948	*Quest for Pure Water*	2,512	2,021	1,874	147	491	8,740.90	8,017.63	790.50
1950	*Water Quality and Treatment* (2nd Edition)	9,300	6,603	5,634	969	2,697	16,426.50	24,491.51	2,685.72
1956	*1940–55 Index*	3,500	1,500	769	731	2,000	4,414.21	3,099.43	2,173.97
	Manual								
1954	*Water Rates* (M1)	2,200	2,200	1,534	666		1,004.90	1,566.47	157.18
1955	*Silent Service* (M2)	5,038	2,538	687	1,851	2,500	1,067.41	740.87	749.17
1956	*Safety Practice* (M3)	3,000	3,000	2,585	415		1,511.11	3,132.25	171.81

a. Manual of Water Works Accounting. Sales: 46 copies in 1958; 118 in 1957; 87 in 1956.

With only 112 copies of the accounting manual left, some thought should be given to its reprinting, revision, or replacement. As the text now remains unchanged from its first appearance in 1938, it obviously does not include coverage of the requirements of electronic accounting procedures and any other

innovations in the field since that date. Reprinting or revision of the book will, of course, require consultation with its copublishers, the Municipal Finance Officers Assn., but it may be desirable now to consider its replacement with a new volume in the AWWA manual series. It is recommended that a committee be established to review and make recommendations concerning future publication activities in this field. [The Board authorized the appointment of a committee for this purpose.]

b. Survival and Retirement Experience With Water Works Facilities. Sales: 30 copies in 1958; 105 in 1957; 43 in 1956.

c. The Quest for Pure Water. Sales: 53 copies in 1958; 97 in 1957; 48 in 1956.

d. Water Quality and Treatment. Sales: 430 copies in 1958; 482 in 1957; 423 in 1956.

Particularly its continued use as a college text has held sales of *Water Quality and Treatment* at a high level. During 1958, a total of 1,000 additional copies were bound, leaving enough finished books in stock for approximately 2 years' sales. Meanwhile, further consideration is being given to the preparation of a third edition, which now seems desirable if the book is to maintain its reputation as an authoritative text.

One of the considerations involved in plans for a third edition has been the status of ASCE Manual No. 19 on filtration. As indications are that a revised edition of this manual will not be forthcoming for a number of years, it has been suggested to the joint committee involved that it cooperate in strengthening the design information included in *Water Quality and Treatment*, with the idea of equipping that volume to serve the purposes of both books. In discussions with the ASCE representatives, a target date of 1960 for publication of a third edition has been mentioned, and, regardless of the joint committee's decision, this seems a desirable goal. On that basis, it will be necessary promptly to establish and activate the appropriate revision committees, a matter which the Water Works Practice Committee now has in hand.

e. Index to Journal AWWA (1940–55). Sales: 102 copies in 1958; 664 in 1957. More than a matter of promotion, the drop in sales of the *Index* reflects the fact that 1957 was the first sales year for the book. Sales of the *1881–1939 Index* during 1958 totaled 15, leaving only 19 copies in stock.

f. Standard Methods for the Examination of Water, Sewage, and Industrial Wastes. Sales of the tenth edition during 1958 totaled 2,800 copies, bringing total distribution of that edition to approximately 18,000 in the 4 years since its publication, compared with sales of 22,000 of the ninth edition over a period of 9 years.

Progress on the eleventh edition, scheduled for publication in 1960, attained a furious pace as the Joint Editorial Board and the standard methods committees of APHA and FSIWA, as well as AWWA, brought the work of assembling a first draft of the manuscript to a close. It is expected that preparation of the final manuscript, its consideration by the Final Review Committee, and revisions based on that review will require at least until May 15, but before Jun. 1 the approved manuscript should be in the hands of the professional editor who will work with the Joint Editorial Board throughout the publication process.

Working with Michael J. Taras, chairman of the AWWA Standard Methods Committee, on the final stages

of his "supreme effort" will be the AWWA representatives on the Final Review Committee: Ray L. Derby, Harry P. Kramer, and T. E. Larson. Too much praise cannot be given Chairman Taras for his work in the preparation of the "water" portion of the book. Only by devoting all his personal time to the project could he possibly have accomplished so much in so short a time.

7. Manuals

Although no new manuals appeared in 1958, two were put into type and the manuscript of a third was completed. (Full sales and financial data on the three existing manuals are provided in Table 6.)

a. Water Rates Manual. Sales: 203 copies in 1958; 476 in 1957; 167 in 1956.

b. Silent Service Is Not Enough! Sales: 73 copies in 1958; 259 in 1957; 43 in 1956.

c. Safety Practice Manual. Sales: 857 copies in 1958; 738 in 1957; 990 in 1956. As noted earlier, it was the work of some of the safety committees in stocking and selling the manual at sectional and regional meetings that boosted sales even above the good record of 1957. As more and more emphasis is placed on safety and as the new safety award program expands, it is expected that the manual will enjoy continued popularity. Provision has been made in the budget for a new printing that will be needed in 1959.

d. Steel pipe manual. Some controversy within the steel pipe committee concerning one or two of the chapters somewhat delayed final approval of the manuscript, but by the end of 1958 most of the typesetting and drafting for this manual of more than 200 pages had been completed. It is expected to appear sometime in the spring of 1959.

e. Meter manual. Just presented for the Board's approval by the Water Works Practice Committee, the new meter manual has already been considered in the publication plans of the staff. To get this material into print quickly, it is recommended that it be published serially in the JOURNAL first, and then, like the safety manual, be reprinted under a single cover. Not only will this make JOURNAL editorial time available for work on the manual, but it will help bridge the gap in the normal supply of manuscripts that will result from the late convention in 1959. Discussions with Meter Committee Chairman James G. Carns Jr. indicate that it should be possible to complete the serializing of the volume during 1959, so that the manual itself can be made available early in 1960, if not sooner.

f. Education manuals. Of the four in-service training manuals scheduled for preparation under the supervision of the AWWA Education Committee, the one on water utility management was completed in 1958 and is now in type awaiting some bibliographic supplementation, final correction, and makeup. In December the Executive Committee approved plans to proceed on the basis of a first printing of 3,000 copies to be sold at a list price of $2, with discounts for cash sales and for quantity purchases. As this manual figures in the education plans of the Advancement Committee, it is expected that it will receive considerable promotion in the field. The volume should be available by April 1959.

Of the other manuals in this series, the one on distribution is scheduled to be produced next. Its manuscript can be completed in a short time when a production schedule appears possible.

Report of the Committee on Water Utility Advancement

For the Year Ending December 31, 1958

A report of the Committee on Water Utility Advancement for the year ending Dec. 31, 1958, submitted to the AWWA Board of Directors on Jan. 26, 1959, by Fred Merryfield, Chairman.

THE Committee on Water Utility Advancement considers that the ultimate goal of the advancement effort is improved water service. Toward the achievement of this goal its efforts are to be directed into two general but distinct areas: professional advancement and community relations. In this report the committee recommends a general long-term policy, which will be revised as experience indicates. The committee considers it essential to the success of the program that it be motivated by the section advancement committees and implemented in communities through Association members.

It is the intention of the committee that the implementation and direction of the advancement program have the administrative supervision of the Secretary. The committee chairman shall receive from the Secretary such interim reports of the activities carried on in the program and in such detail as he may request. Being cognizant of the progress made by the Association through its members, committees, and staff, the committee will welcome data and assistance from all these services.

Long-Term Policy

Professional Advancement

The objectives of professional advancement are:

1. To provide the tools for self-improvement through education of present and potential water utility managers
2. To improve communication in the water utility field through greater AWWA membership among water utility management
3. To recruit, develop, and retain a professional group of managers through a personnel services program of AWWA
4. To develop support among local governing bodies for local water utility participation in the advancement program and other AWWA activities.

Management Education

A management education program will be established for administration by the section advancement committees employing the business education facilities of universities and colleges.

Information will be developed on administrative management techniques, course outlines and materials, facilities available, and outside cooperative assistance upon which the section committees can draw in establishing their own programs for management education.

Membership

Communication with and participation in the advancement program by a maximum number of water utility managers is imperative for the success of the program. The committee recommends to Association and sectional membership committees particular emphasis on membership recruitment among present managers.

In support of this effort the committee proposes initiation of a water utility management quarterly directed specifically at arousing the interest of community governing bodies and utility policy makers in AWWA membership and participation in the advancement program by their water utility management. This bulletin is to be made available to members upon request (up to ten copies of each issue without charge) for distribution to their community and utility policy makers.

Personnel Services

The development and expansion of a truly professional group of water utility managers is greatly dependent on the provision of job and financial opportunity. The committee therefore proposes the development of an AWWA personnel services program to consolidate the improvement in management performance and recognition toward which the professional advancement program is directed.

Governmental Support

The recognition and support of governing bodies are essential to the success of the program. The committee proposes that this recognition and support be developed through cooperative effort with appropriate agencies and associations in disseminating information.

Community Relations

The committee defines community relations as the local management function of appraising community attitudes toward the utility, identifying and relating utility policies with local community interests, and initiating programs of action to earn community respect and confidence for the utility.

To lend support to local and section efforts in building community relations programs, the committee has delineated four areas of interest toward which its efforts will be directed: all levels of water utility employees; utility customers; utility policy makers; and the public at large. Development of materials and programs will be emphasized in that order. In addition, where practicable, the committee will initiate, on an Association-wide level, through accepted media, materials of general interest which will support local community relations programs.

The committee will continuously review and marshall all aspects of assistance for the program and inform the membership of tools available. Considerable help is available from organizations in other professional fields. Whenever it is indicated that membership in such organizations will benefit the advancement program, the committee chairman will recommend participation by the Association or its representative.

Through its representation on the Advancement Program Liaison Committee, which has the responsibility of coordinating as far as possible the efforts of AWWA, FSIWA, and the Water and Sewage Works Manufacturers Association, the committee will encourage trade and national magazine advertisers to further this program through their advertising copy.

Proposed 1959 Activities

The year 1959 is expected to be one of investigation, appraisal, and trial. The information required to implement the policy on many of the long-term objectives of the committee will be gathered. Suggestion, review, and criticism by the directors, section chairmen, and section advancement committees are to be encouraged.

Professional Advancement

It is anticipated that adequate information can be collected and disseminated to the section advancement committees by midyear, so that the sections will be able to initiate their management education programs during the latter part of 1959 and early in 1960.

The section advancement committee organization is to be completed. During the planning stages of the section management education program, the director, on a consultation basis, is to meet with the section advancement committees and the educational institutions cooperating with them. In promoting these as well as the other activities of the advancement program, the director is to attend as many section meetings as possible.

Management Quarterly

The committee proposes that a water utility management quarterly be developed immediately. By making this bulletin a distinct unit, bound in the center of an issue of *Willing Water* on a quarterly basis, it will be distributed to all members. Order blanks are to be included in the regular pages of *Willing Water* for members who wish to order these bulletins in quantity for their own distribution. Copies are to be orderable in quantity on a single-issue or on a calendar year basis.

Personnel Services Investigation

The committee is to collect information and investigate the activities of various professional, utility, and trade associations in the areas of personnel recruitment, retention, and services. A summary of this information and a suggested program are to be presented for consideration.

Support of Governing Bodies

The committee is to study and participate in the activities of various local governing bodies and appropriate agencies and associations to gain support for the advancement program. Appropriate agencies include such organizations as are composed of public officials who have the responsibility for policy formation and legislation having to do with water utilities.

Community Relations

Efforts will be made to develop and maintain interest in the advancement program from all sources of potential cooperation. Although the committee will encourage such sources of assistance as trade associations, community and professional associations, manufacturers, and service organizations, it is not its intent to give specific sanction to any of them.

It is anticipated that considerable copy writing will be necessary to fulfill the objectives of the committee. Therefore, the employment of professional copy-writing services is recommended in the interest of not expanding or overloading the Association's present staff.

As the employee is the utility's first line of person-to-person communication with the community, the community

relations program will place general emphasis in 1959 on developing an employee relations program for local utilities. Various means and aids for local implementation of employee relations programs will be developed.

In addition to its overall objective in the employee relations field, the committee has reviewed several projects the development and implementation of which it recommends. Among these are: a hometown news program for section meetings, hometown and national coverage of the San Francisco Conference, local film scenarios, a series of brochures or booklets to guide local managers in implementing their community relations programs, and immediate efforts to obtain national advertising support for the program.

Hometown News

The hometown news program is intended to publicize attendance, special events, elections, and awards at section meetings in the hometown media of the members. A procedural outline will be prepared for the use of the section advancement or publicity committee in cooperating with a professional writer who will be assigned as staff for the section committee during the meeting. It is expected that a trade association or cooperating publication in the field will lend the sections the personnel required for this program. A fund to cover the cost of photographs to accompany the publicity prepared will be allotted to the staff personnel by the AWWA Advancement Program. This phase of the program will be directed toward making the members aware of the values and techniques of hometown news coverage.

San Francisco Coverage

For the 1959 Conference hometown and national coverage programs are to be developed. To implement them the committee expects to recruit the assistance of professional publicity personnel of interested organizations.

Film Scripts

Two scripts for use by local utilities in making their own films are to be professionally prepared. One of these will cover the special requirements of ground water systems; the other will cover surface supplies. Provisions for use of local names, terminology, and operational variations will be made. An effort will be made to develop community assistance for the local utility manager in carrying out and financing this effort.

Community Relations Guides

As many brochures or booklets as possible on items of special interest to the local water utility programs will be published. Some of the subjects now contemplated are:

1. Facts about water (for editors and speechmakers)
2. A "Water Utility Day"
3. A water utility open house
4. A water utility school program
5. A water utility referendum
6. Placing water utility news.

Liaison Activity

Through its representation on the Liaison Committee, the Committee on Water Utility Advancement will promptly endeavor to obtain the cooperation of trade and national magazine advertisers in furthering the overall objectives of its program.

Report of the Audit of Association Funds

For the Year Ending December 31, 1958

To the Members of the American Water Works Association:

The By-Laws require that the Secretary have an audit made annually of the books of the Association.

The records for 1958 have been examined by the staff of Louis D. Blum & Co. The complete record of that examination follows.

Audits have been published in the JOURNAL annually since 1937. They have appeared either in the March or April issue.

Respectfully submitted,
HARRY E. JORDAN
Secretary

January 28, 1959

TO THE AMERICAN WATER WORKS ASSOCIATION:

We have examined the balance sheet of the American Water Works Association as of December 31, 1958, and the related statements of income and surplus for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet as of December 31, 1958, and the related statements of income and surplus present fairly the financial position of the American Water Works Association at that date and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(Signed)

LOUIS D. BLUM & Co.
Certified Public Accountants

EXHIBIT A—Balance Sheet

December 31, 1958

Assets

Cash in Banks and on Hand		$ 84,317.08*
Accounts Receivable:		
Membership dues	$ 722.50	
Advertising—Journal	9,220.33	
Reprints	799.23	
Sundry standards	577.93	
The Story of Water Supply (booklet)	241.66	
Other	991.01	12,552.66
Accrued Interest on Bonds		1,574.41
Inventories:		
Paper stock	8,673.98	
Type metal	2,997.38	
Water Quality and Treatment (book)	2,685.72	
Manual of Water Works Accounting (book)	166.88	
Water Rates Manual (manual)	157.18	
Sundry standards	2,598.57	
Quest for Pure Water (book)	790.50	
Survival and Retirement (book)	922.16	
Willing Water novelties	202.25	
Cumulative Index—1881–1939	22.80	
Cumulative Index—1940–1955	2,173.97	
Your Water Supply (booklet)	1.30	
The Story of Water Supply (booklet)	3,697.83	
Silent Service Is Not Enough! (manual)	749.17	
Safety Practice for Water Utilities (manual)	171.81	
What Price Water (booklet)	389.42	
Back Issues—Journal—Vol. 1–50, inclusive (40,036 copies)	—†	
Back Issues—Proceedings—1881–1913, inclusive (240 copies)	—†	26,400.92
Office Equipment (less depreciation)		17,408.20
Investments at Cost (Schedule 1)		112,825.00
Deferred Expenses		5,764.05
Deposits—Airlines and Postage		925.00
Total Assets		$261,767.32

Liabilities and Surplus

Accounts Payable	$ 4,631.33
Membership Dues—Advance Payments	99,350.45
Unearned Subscriptions to Journal	6,323.16
Advance on Publication	5,000.00
Reserve for Award Fund (McCord)	53.02
Senior Members Contributory Fund	4,992.50
Miscellaneous	101.63
Surplus, per Exhibit C	141,315.23
Total Liabilities and Surplus	$261,767.32

* At December 31, 1958 the cash balance as shown on the cash statement prepared by management was $80,746.97. The difference of $3,570.11 represents a check drawn in December 1958 but not delivered as at the year end for the reason that negotiations for a reduction of the amount in question were pending. This amount was subsequently adjusted and a reduced amount was paid in January 1959.

† Back issues of Journals and Proceedings are inventoried but no money values are assigned to them for balance sheet purposes inasmuch as the entire costs were charged off during the year of publication. The quantity shown is in accordance with a tabulation supplied by the Association's printer.

EXHIBIT A, SCHEDULE 1—INVESTMENTS, DECEMBER 31, 1958

Description	Interest Rate %	Principal Amount	Cost	Quoted Market or Redemption Value Dec. 31, 1958
Foreign Securities:				
Province of Ontario	4	$ 1,000.00	$ 732.50	$ 990.00*
Government of Canada, 6th Victory Loan	3	2,000.00	2,000.00	2,020.00†
Hydro Electric Power Commission of Ontario	2.75	5,000.00	5,075.00	4,387.50†
Province of Ontario	3	2,000.00	2,022.50	1,850.00†
Hydro Electric Power Commission of Ontario	3	2,000.00	2,020.00	1,852.50†
Government of Canada	3	5,000.00	4,775.00	4,712.50†
US Government Securities:				
US Savings Bonds, Series:				
G	2.5	7,000.00	7,000.00	6,944.00‡
G	2.5	7,500.00	7,500.00	7,342.50‡
G	2.5	2,500.00	2,500.00	2,417.50‡
G	2.5	1,000.00	1,000.00	964.00‡
K	2.76	5,000.00	5,000.00	4,835.00‡
K	2.76	2,000.00	2,000.00	1,932.00‡
K	2.76	25,000.00	25,000.00	24,150.00‡
K	2.76	10,000.00	10,000.00	9,670.00‡
K	2.76	10,000.00	10,000.00	9,750.00‡
US Treasury Bond	4	10,000.00	10,000.00	10,156.25
Utilities:				
Consumers Power Company Bonds	4.75	5,000.00	5,431.25	5,243.75
Pacific Gas and Electric Co. Bonds	4.50	5,000.00	5,362.50	5,103.13
American Telephone and Telegraph Bonds	5.00	5,000.00	5,406.25	5,390.63
		$112,000.00	$112,825.00	$109,711.26

* This security is payable in United States funds.
† These securities are payable in Canadian funds. Market value represents value in New York in United States funds.
‡ These amounts represent redemption value on December 31, 1958.

EXHIBIT B—STATEMENT OF INCOME AND EXPENSES
FOR THE YEAR ENDED DECEMBER 31, 1958

Operating Income:		
Annual dues	$132,967.25	
Advertising—Journal	131,758.95	
Advertising—Directory	9,186.00	
Subscriptions to Journal	10,463.85	
Convention:		
Registration fees	36,770.00	
Ticket sales	3,462.00	
Other events	61.82	
Water and Sewage Works Manufacturers Assn.	7,500.00	
Interest and dividends on investments	3,984.00	
Miscellaneous income	110.40	
TOTAL OPERATING INCOME (carried forward)		$336,264.27

TOTAL OPERATING INCOME (brought forward)			$336,264.27
Publication Income:			
Water Quality and Treatment (book)		1,945.43	
One-third of profit from sales of Standard Methods (book)		5,977.27	
Manual of Water Works Accounting (book)		173.05	
Water Rates Manual (manual)		241.62	
Sundry standards		12,202.71	
Proceedings and Journals		1,814.86	
Quest for Pure Water (book)		210.75	
Survival and Retirement (book)		73.97	
Willing Water novelties		1,420.64	
Reprints		7,836.68	
Silent Service Is Not Enough! (manual)		83.75	
Public relations material		363.59	
Your Water Supply (booklet)		1,659.76	
The Story of Water Supply (booklet)		7,314.87	
Cumulative Index—1881–1939		30.65	
Cumulative Index—1940–1955		422.53	
Safety Practice of Water Utilities (manual)		1,027.30	
What Price Water (booklet)		1,844.41	
Sound slide film		1,120.00	
Research fund		1,000.00	
Miscellaneous		116.40	
TOTAL PUBLICATION INCOME			46,880.24
TOTAL INCOME (carried forward)			$383,144.51
Operating Expenses:			
Directors' and Executive Committee Meetings:			
Travel expense		$ 9,160.44	
Administrative Expenses:			
Rent	$13,500.00		
Office supplies and services	19,999.61		
Membership promotion	1,228.27		
Pension—Secretary Emeritus	2,500.00		
Contributions to pension system	8,343.99		
Legal and auditing expenses	6,156.32		
General and special travel	1,986.88		
Federal activities	340.04		
Social security taxes	1,352.57		
Secretary's special expense	2,500.00		
Hospitalization insurance	529.98	58,437.66	
Administrative Salaries		108,068.19	
Committee Expense		860.43	
Division and Section Expenses:			
Section—membership allotment	25,402.66		
Section—travel expense	5,667.30		
Section—general expense	805.94	31,875.90	
Journal:			
Printing	66,207.72		
Production	7,866.70		
Paper	25,030.27		
Directory	13,465.97	112,570.66	
OPERATING EXPENSES (carried forward)		$320,973.28	

TOTAL INCOME (brought forward)			$383,144.51
OPERATING EXPENSES (brought forward)		$320,973.28	
Convention:			
General	12,484.63		
Entertainment	23,598.34	36,082.97	
Membership Dues in Other Associations		3,082.00	
Depreciation of Office Equipment		2,829.03	
Miscellaneous		3,056.66	
TOTAL OPERATING EXPENSES		$366,023.94	
Cost of Publications Sold:			
Water Quality and Treatment (book)	$ 828.05		
Standard Methods (book)	567.72		
Manual of Water Works Accounting (book)	106.84		
Water Rates Manual	47.90		
Sundry standards	5,295.06		
Proceedings and Journals	2.70		
Quest for Pure Water (book)	106.85		
Survival and Retirement (book)	54.06		
Willing Water novelties	1,174.51		
Reprints	5,903.43		
Silent Service Is Not Enough! (manual)	20.01		
Public relations material	829.54		
Your Water Supply (booklet)	850.45		
The Story of Water Supply (booklet)	4,360.19		
Cumulative Index—1881–1939	18.00		
Cumulative Index—1940–1955	257.75		
Safety Practice for Water Utilities (manual)	422.48		
Special handling and postage charges	2,008.39		
What Price Water (booklet)	871.75		
Sound slide film	1,180.63		
Research fund	1,000.00		
Management manual	77.60		
Miscellaneous	96.75	26,080.66	
Development Activities:			
Public relations	13,084.49		
General publicity	17,232.87		
Safety awards	253.15	30,570.51	
TOTAL EXPENSES			422,675.11
Net Income for the Year (Transferred to Exhibit C)			$(39,530.60)*

EXHIBIT C—STATEMENT OF SURPLUS FOR THE YEAR ENDED DECEMBER 31, 1958

Balance, January 1, 1958	$180,845.83
Deduct: Net loss for the year, per Exhibit B	(39,530.60)*
Balance, December 31, 1958, per Exhibit A	$141,315.23

* Negative figure.

American Water Works Association Pension System

BALANCE SHEET—DECEMBER 31, 1958

Assets

Cash in bank	$ 20,144.84
Accrued bond interest	829.16
Investments (Schedule 1)	114,073.75
TOTAL ASSETS	$135,047.75

Liabilities and Reserve for Future Benefits

Liability for refund of employees' contributions plus earned interest	$ 14,293.84
Reserve for future benefits	120,753.91
TOTAL LIABILITIES AND RESERVE	$135,047.75

STATEMENT OF RECEIPTS AND DISBURSEMENTS FOR THE YEAR 1958

Item	Cash	Reserve for Future Benefits	Liability for Refund of Employees' Contributions	Due to AWWA
Receipts:				
Association contributions	$ 8,343.99	$ 8,343.99	$ —	$ —
Employees' contributions	2,260.02	—	2,260.02	—
Interest on bonds	3,402.68	3,402.68	—	—
Interest on savings account	23.20	23.20	—	—
Government bond, Series G, matured Dec. 1, 1958	10,000.00	—	—	—
Total	24,029.89	11,769.87	2,260.02	—
Disbursements:				
Investment in bond	4,200.00	—	—	—
Refund of contributions plus interest	199.12	—	199.12	—
Audit and legal expense	725.00	725.00	—	—
Office expenses	38.18	38.18	—	—
Refund of interest	43.75	—	—	43.75
Total	5,206.05	763.18	199.12	43.75
Excess of Cash Receipts Over Disbursements	18,823.84	11,006.69	2,060.90	(43.75)*
Adjustments for Non-Cash Items:				
Interest credited to employees accounts	—	(357.18)*	357.18	—
Interest accrued on bonds, Jan. 1, 1958	—	(783.33)*†		—
Interest accrued on bonds, Dec. 31, 1958	—	829.16‡		—
	—	(311.35)*	357.18	—
Additions to accounts for year	18,823.84	10,695.34	2,418.08	(43.75)*
Balance, January 1, 1958	1,321.00	110,058.57	11,875.76	43.75
Balance, December 31, 1958	$20,144.84	$120,753.91	$14,293.84	$ —

* Indicates red figures.
† Accrued interest receivable as per balance sheet Dec. 31, 1957.
‡ Accrued interest receivable as per balance sheet Dec. 31, 1958.

SCHEDULE 1—INVESTMENTS, DECEMBER 31, 1958

Description	Interest Rate %	Cost	Maturity Date
Bonds Registered in Name of Administrative Committee:			
United States Securities:			
US Savings Bonds:			
Series G	2.5	$ 10,000.00*	1961
Series G	2.5	10,000.00*	1962
Series G	2.5	14,000.00*	1963
Series K	2.76	9,000.00*	1964
Series K	2.76	17,000.00*	1965
Series K	2.76	9,000.00*	1966
Series K	2.76	9,000.00*	1967
Series K	2.76	20,000.00*	1968
Utilities:			
Consolidated Edison Co. bonds	2.75	4,200.00†‖	1982
American Telephone & Telegraph Company bonds	5.00	6,480.00‡	1983
Consumer Power Company bonds	4.75	5,393.75§	1987
Total		$114,073.75	

* Redemption value on December 31, 1958—$95,050.00.
† Market value on December 31, 1958—$3,837.50.
‡ Market value on December 31, 1958—$6,468.75.
§ Market value on December 31, 1958—$5,243.75.
‖ Acquired in 1958.

1958 Section Membership Awards

Old Oaken Bucket		Hill Cup		Henshaw Cup	
Section	Score*	Section†	Score‡	Section	Score§
California	1,583	California	37.365	Pacific Northwest	75.0
Southwest	1,060	Arizona	33.600	Intermountain	71.1
New York	882	Florida	28.424	California	63.8
Canadian	729	Michigan	26.760	Montana	62.5
Illinois	669	West Virginia	26.333	West Virginia	54.5
Pennsylvania	547	Illinois	17.119	Iowa	52.9
Indiana	528	Iowa	16.296	Southeastern	51.1
New Jersey	526	New Jersey	13.629	Michigan	49.1
Michigan	512	Chesapeake	13.570	Indiana	46.3
Ohio	506	Indiana	11.380	Wisconsin	45.8
Pacific Northwest	478	Missouri	11.296	Arizona	44.2
Florida	374	Alabama-Mississippi	10.452	Ohio	43.5
Southeastern	308	Canadian	8.990	Alabama-Mississippi	41.3
Chesapeake	305	Pacific Northwest	8.768	Kentucky-Tennessee	41.0
Kentucky-Tennessee	257	Wisconsin	8.734	Illinois	40.8
New England	257	Kentucky Tennessee	5.958	Kansas	39.8
North Central	252	Southwest	5.187	Florida	36.6
Missouri	243	New York	3.712	Virginia	36.6
Kansas	238	Kansas	3.330	North Central	33.5
Alabama-Mississippi	230	Ohio	3.321	New Jersey	29.9
Wisconsin	212	Southeastern	2.852	Pennsylvania	26.8
Virginia	209	Cuban	1.812	Chesapeake	20.9
Rocky Mountain	204	Montana	‖	Canadian	#
North Carolina	202	Nebraska	‖	Cuban	#
Iowa	193	New England	‖	Missouri	#
West Virginia	113	North Carolina	‖	Nebraska	#
Nebraska	104	North Central	‖	New England	#
Arizona	100	Pennsylvania	‖	New York	#
Intermountain	80	Rocky Mountain	‖	North Carolina	#
Montana	60	Virginia	‖	Rocky Mountain	#
Cuba	59			Southwest	#

* Numbers of members.
† Intermountain Section not eligible in 1958.
‡ Weighted gain in membership.
§ Percentage of members present at annual meeting.
‖ Minus score.
Data not available or section not competing.

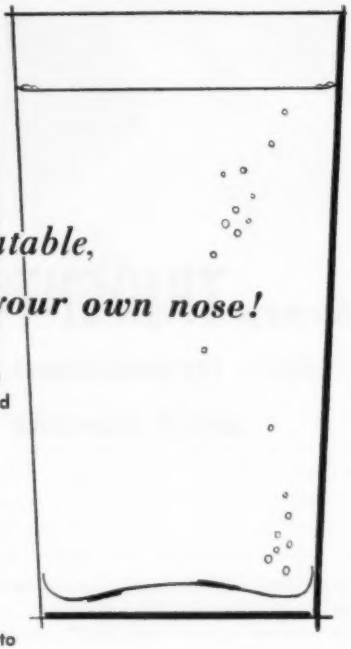
AWWA Membership Growth

Membership Statement—Year of 1958

	Active	Corporate	Munic. Serv. Subscriber	Associate	Honorary	Life	Junior	Total
Total members, Dec. 31, 1957	9,608	942	271	365	42	364	60	11,652
Change of grade, 1958	−14				4	28	−18	
	9,594	942	271	365	46	392	42	11,652
Gains:								
New, 1958	1,242	75	45	9		1	32	1,404
Reinstated, 1958	103	2	3	2		1		111
	10,939	1,019	319	376	46	394	74	13,167
Losses:								
Resignations and deaths, 1958	−267	−29	−6	−9	−1	−18		−330
Dropped for nonpayment, 1958	−516	−24	−15	−10			−5	−570
TOTAL MEMBERS, Dec. 31, 1958	10,156	966	298	357	45	376	69	12,267
Net gain in 1958	548	24	27	−8	3	12	9	615

Comparative Statement—Gains and Losses—25-Year Period

Year	New	Reinstated	Resignations and Deaths	Suspended for Nonpayment of Dues	Gain or Loss	Total Members at End of Year
1934	271	66	86	122	129+	2,350
1935	565	42	85	190	332+	2,682
1936	311	53	104	218	42+	2,724
1937	515	86	122	139	340+	3,064
1938	520	59	144	140	295+	3,359
1939	578	64	122	179	351+	3,710
1940	514	58	113	212	247+	3,957
1941	480	92	116	236	220+	4,177
1942	570	59	132	233	264+	4,441
1943	769	88	130	198	529+	4,970
1944	734	92	140	171	515+	5,485
1945	543	56	111	235	253+	5,738
1946	816	79	168	324	403+	6,141
1947	933	74	143	349	515+	6,656
1948	847	81	207	347	374+	7,030
1949	1,083	75	196	323	639+	7,669
1950	852	58	128	421	361+	8,070
1951	1,090	63	199	441	513+	8,583
1952	1,005	66	232	505	334+	8,917
1953	1,077	99	263	370	543+	9,460
1954	1,160	69	256	493	480+	9,940
1955	1,244	90	270	578	486+	10,426
1956	1,424	118	284	611	555+	11,073
1957	1,425	96	243	699	579+	11,652
1958	1,404	111	330	570	615+	12,267



to be sure

your water is always palatable,

it pays to look beyond your own nose!

Objectionable tastes and odors can frequently go undetected because operators become conditioned to plant odors.

So it is sound practice to make daily threshold odor tests to detect and accurately measure variations in water tastes and odors. Consistent PALATABILITY can then be assured with AQUA NUCHAR in controlled dosage to meet changing day-to-day conditions.

AQUA NUCHAR adsorbs all tastes and odors due to algae, decaying vegetation, trade-wastes and other causes. Properly applied, it is the only method that is universally effective. And because of the low concentrations required (as little as 2 to 5 ppm average) it is economical as well.

Our field technical service staff is available without obligation to make a threshold odor survey of your plant. For information write or phone us today.

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Activated Carbon for Taste and Odor Control

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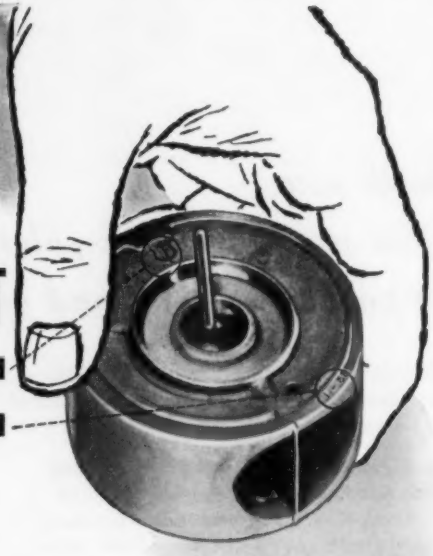

Every TRIDENT
Unit Identified
and Dated

Trident water meters are precision instruments . . . every part made to extremely close tolerances . . . every material carefully selected and tested to give longest life in *your* water system.

Most important, every improvement made in new Trident meters immediately becomes available in repair parts for your older meters. You re-order only the latest parts. As you replace worn, out-dated parts over the years, your Tridents are *automatically* modernized.

for your protection

To protect you from substitutes . . . and to make sure you're getting the benefits of Neptune progress . . . the Trident trademark is put on most all Trident parts . . . and the *date* is put on every major Trident part. Take a look at these date marks. They show you how well Tridents last. They also show you how your older meters have been kept up to date over the years with improved Trident repair parts.

Insist on genuine Trident parts . . . and check to be certain.

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TRIDENT WATER METERS

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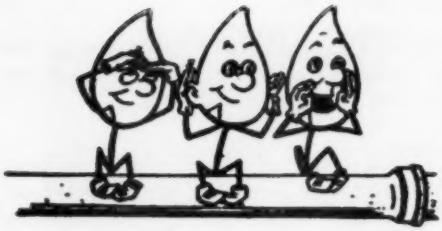


Percolation and Runoff

The 'water shortage' that finally made "news" of the story of water supply, like so many headline gimmicks that work, is by now beginning to be believed even by those who created it as a justifiable means of bringing a critical problem to the attention of the public. Lest those responsible for planning and promoting the solution to the problem also be taken in, we hasten to remind them that it's not the water but the works that are in short supply.

The clouds still favor the United States with approximately 4,300 bgd, of which, the USGS estimates, 1,300 bgd are available as percolation and runoff. Current US water use for all purposes is estimated at 300 bgd. Thus, even if water were to be used only once before being returned to the clouds, supply would be more than four times demand. But it is known that water can be used at least five times even as public water supply before it needs to be rerained. Although this suggests that supply is at least twenty times present demand, it is well to remember, too, that public water systems require less than 7 per cent—approximately 20 bgd—of the total water now used. And if even a supply 325 times public water supply requirements seems none too long, be cheered by the news that sea water desalting procedures are constantly being improved (see this issue, P&R p. 38) and that scientists exploring the polar regions as a project of the International Geophysical Year have determined that the world's frozen assets—that is, its fresh water in the form of ice—are actually 1,250,000 cu mi greater than the 3,250,000 cu mi previously estimated. Applying the factor of five possible reuses to these supplies, we can point out that, to obtain their 20 bgd, public water utilities have a fairly high-priority claim to the equivalent of 6,500 bgd of rainfall and of at least a lamb's share of 18,000,000 cu mi of ice and 35 seafuls of salt water.

What we are trying to express, of course, is a hope that the "shortage" that didn't exist will soon be over. Frightening the public into thinking that there is a water shortage may be a legitimate means of arousing its interest. Convincing the public that there is a water shortage may even be an ingenious way of excusing inadequate water service. But only when the public realizes that there is no water shortage—that, given adequate support, water utilities can provide all the water the public needs, when and where it needs it—will "improved water service" be possible.

(Continued on page 36 P&R)

(*Continued from page 35 P&R*)

If, from never saying boo about water, our communicators moved to saying BOO too often, who can complain? But now the shortage that needs their attention seems to be "facts about" rather than "interest in" water supply. And, of course, facts can be booful, too!

Admiral of the Detroit River appears to be another admiralty (see February P&R, p. 36) that has been earned by, if not yet conferred upon, an AWWA member—Leo Garrity, engineer in charge of building the new $50,000,000 Wayne County, Mich., water plant and chairman of AWWA's Michigan Section. Unlike his titular equals in the Association, Leo actually has a "navy," consisting of a cruiser (28 ft, cabin) and crew (2 seamen), used to transport men and equipment from a Wyandotte pier to the intake station now abuilding in Canadian waters more than a mile away.

As a matter of fact, the Board of Wayne County Road Commissioners, which commissioned Leo, would probably be happy to assign his navy, considerably reinforced, to combat duty if they thought it could help them in some of the legal and political battles that have been hampering the project ever since it was undertaken. The underground—not to be confused with Admiral Leo's underwater forces (2 divers)—now has it that the city of Detroit, which has opposed the county system from the beginning on the basis that it was unnecessary and which has been fighting it in the courts, will now permit its completion if the commissioners agree to sell the finished plant to the city.

Even without knowing the inside story, we have an idea that, before the battle is over, the plant is bound to be necessary, so we're rather hoping that neither the admiral's commission nor his fleet gets mothballed.

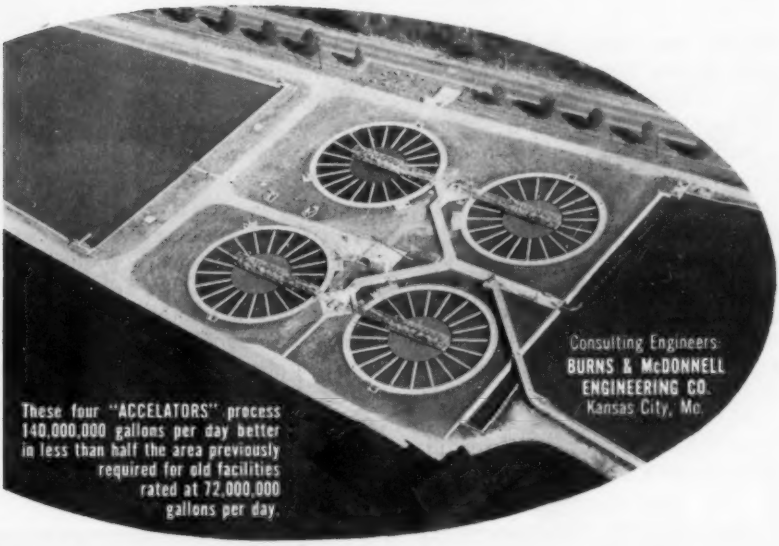
Lewis S. Finch, AWWA president, has been named "Engineer of the Year" by the Indiana Society of Professional Engineers. President Finch is chief engineer (and vice-president) of Indianapolis Water Co.

Calling a spa a shpa was the Franklinton, N.C., Chamber of Commerce last month when the local water supply suddenly became the biggesht asshet the town had. Actually, first indications of the transformation were hardly encouraging, being manifested in a series of bitter complaints about the queer taste and odor in the water. But, when the reason began to make itself felt, it is understood that everyone was happy about the whole thing.

It all started when revenue agent Graham Copeland and his men raided a still a mile west of town and dumped several thousand gallons of mash, beer, and hard liquor into a small stream nearby. What they didn't know was that, a few hundred yards below the site of the still, the stream emptied into the Franklinton Water Dept. reservoir, wherein the still spill collected into a king-size cocktail. Three days later came the complaints, putting Department Manager C. G. Hight into feverish action with chemicals to counteract the taste and odor, and, then, the complimensh, putting him on the trail of the cause.

Although it is intimated that the Franklinton supply at its best tested to 40 proof, we take this estimate with a dash of bitters. Still, it musht have been fun.

(*Continued on page 38 P&R*)


These four "ACCELATORS" process 140,000,000 gallons per day better in less than half the area previously required for old facilities rated at 72,000,000 gallons per day.
Consulting Engineers:
BURNS & McDONNELL ENGINEERING CO.
Kansas City, Mo.

OMAHA CHOOSES INFILCO EQUIPMENT
for World's Largest High-rate Water Treating Plant

... saves hundreds of thousands
... doubles production in half the space with latest ACCELATOR® clarifying units

The Metropolitan Utilities District of Omaha and their Consulting Engineers, Burns & McDonnell, selected solids-contact units for the treatment of Missouri River water because extensive studies and evaluation of competitive bids proved that ACCELATOR® units provided the greatest capacity in the limited space available.

Each "ACCELATOR" basin is 120' in diameter by 27'6" deep. Each is guaranteed to produce high quality effluent at minimum chemical cost and have a capacity of 35 m.g.d. with water temperature above 65° F. or 20 m.g.d. below 35° F.

Performance tests have demonstrated that each "Accelator" unit will clarify 41 m.g.d. with water above 65° F. and at least 31 m.g.d. with 35° F. water—using even less chemicals than were indicated in laboratory jar tests; and produced effluent turbidities substantially less than 10 ppm. Subsequent operation under hardness reduction conditions has produced even better results.

These are typical of the results being obtained in more than 2500 "ACCELATOR" installations, treating every type of water for municipal and industrial use. For more complete information write today for Bulletin 1825-D.

Inquiries also invited on coagulation, precipitation, sedimentation, filtration, flotation, aeration, ion exchange and biological processes.

INFILCO INC., General offices — Tucson, Arizona
Field offices throughout the United States and other countries

INFILCO

Eminence in design for water, sewage and waste treating and processing equipment... since 1894

(*Continued from page 36 P&R*)

By the sea seems to be the most popular answer these days to the question of how our future problems of water supply will be solved. And it has been under the leadership of the US Dept. of Interior that this answer has been receiving its most intensive exploration of late. Having been granted $10,000,000 by Congress to set up five experimental demonstration plants, the department already has a contract with Carrier Corp. for a plant using a new direct-freeze process and with Fluor Corp. to study the feasibility of a nuclear-powered conversion plant at Whittier, Calif. Solar distillation, flash evaporation, and electric membrane methods are also scheduled for investigation in the program.

Meanwhile, many others have also gone to sea. Southern California Edison Co., for instance, recently awarded a $100,000 contract to Cleaver-Brooks Special Products, Inc., for construction of a 100,000-gpd experimental evaporation unit at Edison's new steam plant near Oxnard, Calif. The New York State Thruway Authority has installed the "first commercial saline-water conversion plant east of the Mississippi River" at one of its restaurants to demineralize 12,000 gpd of a brackish well water in an Ionics, Inc., unit employing permselective membranes. At

The Aruba saline-water conversion plant in the Dutch West Indies uses the Caribbean Sea as its source. Fresh water is stored in the four tanks, in front of which are the evaporators.

(*Continued on page 40 P&R*)

You buy
greater
DEPENDABILITY
with
WATCH DOG
WATER METERS
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GAMON METER DIVISION
NEWARK
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WORTHINGTON

(*Continued from page 38 P&R*)

San Diego, Calif., a bottled-water company has installed a 60,000-gpd demonstration solar-heat converter designed by one Edward Morris, "a hydraulics engineer and authority on California's resources" who financed his own research efforts. At Tel Aviv, Israel, government authorities announced work on a pilot plant using a freezing process invented by Alexander Zarchin, a refugee engineer from the Soviet Union. And in Aruba, Dutch West Indies, the world's largest single installation for converting sea water—a $10,000,000, 2.7-mgd, multiple-effect distillation plant designed and constructed by Singmaster & Breyer, New York engineers—went into operation.

With all this experimenting and experience and with an increasing number of manufacturers getting interested in the field, speculation concerning a "cost breakthrough" has been brightening. Cleaver-Brooks notes that it has produced 4,000 sea water conversion units in the past 12 years, with a total fresh-water capacity of 16 mgd. Ionics, Inc., points to fifteen installations in the Middle East, as well as to its recent 28,000-gpd unit for public supply in Coalinga, Calif. Maxim Silencer Div. of Emhart Corp. is particularly proud of its installation at the Castle Harbor Hotel in Bermuda. The Mechanical Equipment Co., Inc., catalogs a complete distillation line from the 15-gph size to "the world's largest thermocompression unit." Others in the field, including Westinghouse International, Badger Mfg. Co., and Griscom Russell Corp., are hard at the look-sea business, aiming to put the main in our mains at a competitive price. Actually, of course, the "breakthrough" is an individual matter—at Aruba and Coalinga and a few other places it has already been achieved. As far as the normal community is concerned—even the normal coastal community—we still say: long time no sea.

How long no sea may be suggested by a review of the early British patents for purification and filtration of water. Between 1675 and 1790 only four patents were granted under this category, all of them covering methods of desalting sea water. First, William Walcott on Oct. 28, 1675, was granted Patent No. 184 for the:

> Art of makeing water corrupted fitt for vse, and sea water fresh, cleare, and wholesome in very large quantities, by such wayes and means as are very cheap and easy, and which may bee done and practised with great speed and expedicon.

Then a research team of Robert Fitzgerald, Theophilus Oglethorpe, William Bridgeman, Patrick Trant, and Thomas Maule on Jun. 9, 1683; Bartholomew Dominiceti, on Dec. 6, 1770; and, finally, Alexander Mabyn Bailey, on Jul. 19, 1777, developed machines and methods that were, in turn, to prove "of great and public vse, both at land and sea." Being the latest of these, Bailey's was the most complicated and, also, the most useful, covering the making of salt as well as the production of water:

> A machine for making fresh water from sea water or brine springs without boiling, which will be pure element without spirit of salt, bitumen, heterogeneous matter, and for making salt from sea water, or from brine springs, with much less boiling than in the common way of boiling it. This machine may be worked by hand, horse, wind, or water.

From 1675 through 1866 almost a hundred of the approximately 3,400

(*Continued on page 42 P&R*)

HIGH-RATE WATER TREATMENT

WITH GRAVER REACTIVATORS®

MEETS THE NEEDS OF HIGHLAND PARK, MICHIGAN

With the growing demand for water by community and industry, the City of Highland Park outgrew its conventional settling plant and old pumping station. To meet its needs, Highland Park built a booster pumping station and installed a high-rate treatment system consisting of two 11 mgd Graver Reactivators. Each of the units is 80 ft. sq. x 21 ft. 6 in. high.

The Graver Reactivator is an up-flow solids-contact unit which incorporates four distinctive design features geared to provide effective clarification. These features are controlled sludge recirculation, low sludge level, separately driven and variable speed impeller and overall sludge removal.

At Highand Park, water supply is drawn from a lake water which forms very light floc and might have been difficult to clarify. But the Graver Reactivators have proved ideal for this water because their design features work together to provide the effective floc formation which results in excellent removal of turbidity.

To-date, the Graver Reactivators have delivered clarified water with turbidities not exceeding 0.3 parts per million. Effluent from the filter plant is so pure that it is difficult to measure accurately.

GRAVER

Municipal Water Treatment Dept. M-421
GRAVER WATER CONDITIONING CO.
Division of Union Tank Car Company
216 West 14th Street, New York 11, N. Y.

Write for the complete story of Highland Park in a new reprint, T-164.

(*Continued from page 40 P&R*)

British patents granted described such "cheap and easy" ways to desalt sea water, not then because of the expected inadequacy of nature to keep up with the requirements of man, but because British seamen liked fresh water with their grog.

All of which is to suggest that *My Fair Lady* will be celebrating its 200th birthday before any Eliza will be prompted to enunciate: "The main in Maine is mainly in the mains."

Leo Louis Jr., vice-president and general manager of Gary-Hobart Water Corp., Gary, Ind., has been appointed to the National Defense Executive Reserve of BDSA.

Keasbey & Mattison Co., Ambler, Pa., manufacturer of asbestos, asphalt, and heat insulation products, has made a number of personnel changes in its sales division. D. W. Widmayer, moves from director of sales to marketing consultant. Norman L. Barr, formerly general sales manager of the Asbestos-Cement Pipe Div., becomes general sales manager of the Sales Div. Succeeding Barr is James R. Reichel, previously district sales manager at San Francisco, a post being taken by John L. Prechek.

C. F. Wertz (left), director, Miami, Fla., Dept. of Water & Sewers, backs up Chief Engineer Sloan as he receives a safety award from James S. Fulton, safety engineer for Bituminous Casualty Corp.; Joe Brown, the department's personnel and safety supervisor, smiles approval. The award was earned by a record of no accident or injury during the fiscal year of 1957–58.

(*Continued on page 46 P&R*)

Reilly

230 X-1

Primer

QUICKLY

adds extra staying power to hot application fully plasticized enamels

It creates a bond between fully plasticized coal tar enamel and metal that strengthens as it serves... that, when properly applied, increases the reliability factor of the application process on steel pipe and tank surfaces to a comfortable 100%.

Reilly 230 X-1 Primer

Reilly 230 X-1 Primer is

1. Quick drying, 20 minutes ± in clean atmosphere at 70°F.
2. Non-sagging and non-curtaining.
3. Economical to use (750 to 1400 sq. ft. gal. coverage).
4. Derived wholly from coal tar materials.
5. Acceptable to A.W.W.A. and government standards.

Specify REILLY 230 A. W. W. A. enamel with 230 X-1 primer. Also, soon to come, HS X-1 for Hot Service and QD-X-1 for Intermediate enamel.

REILLY TAR & CHEMICAL CORPORATION

1615 MERCHANTS BANK BUILDING
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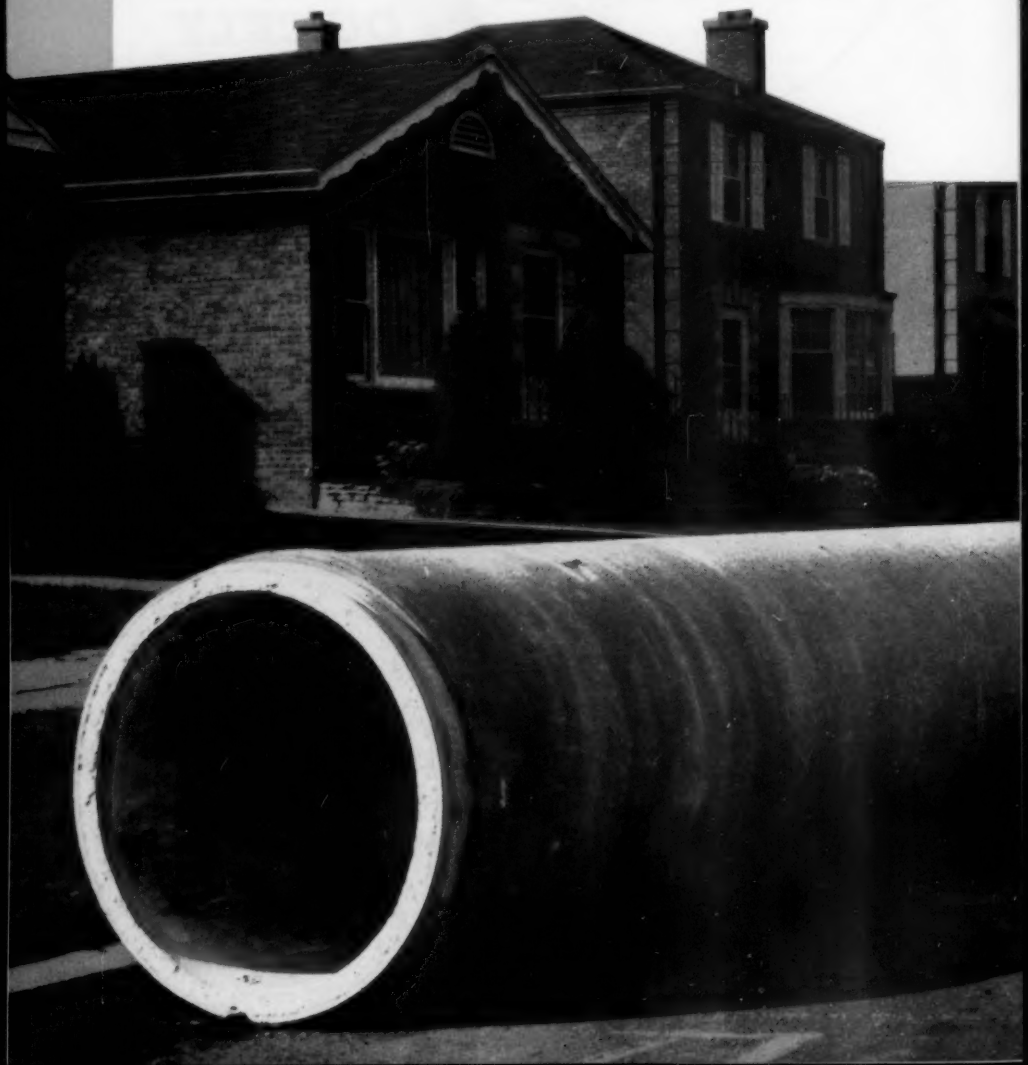
YOU'RE ON

EASY STREET

With Water Distribution Lines of

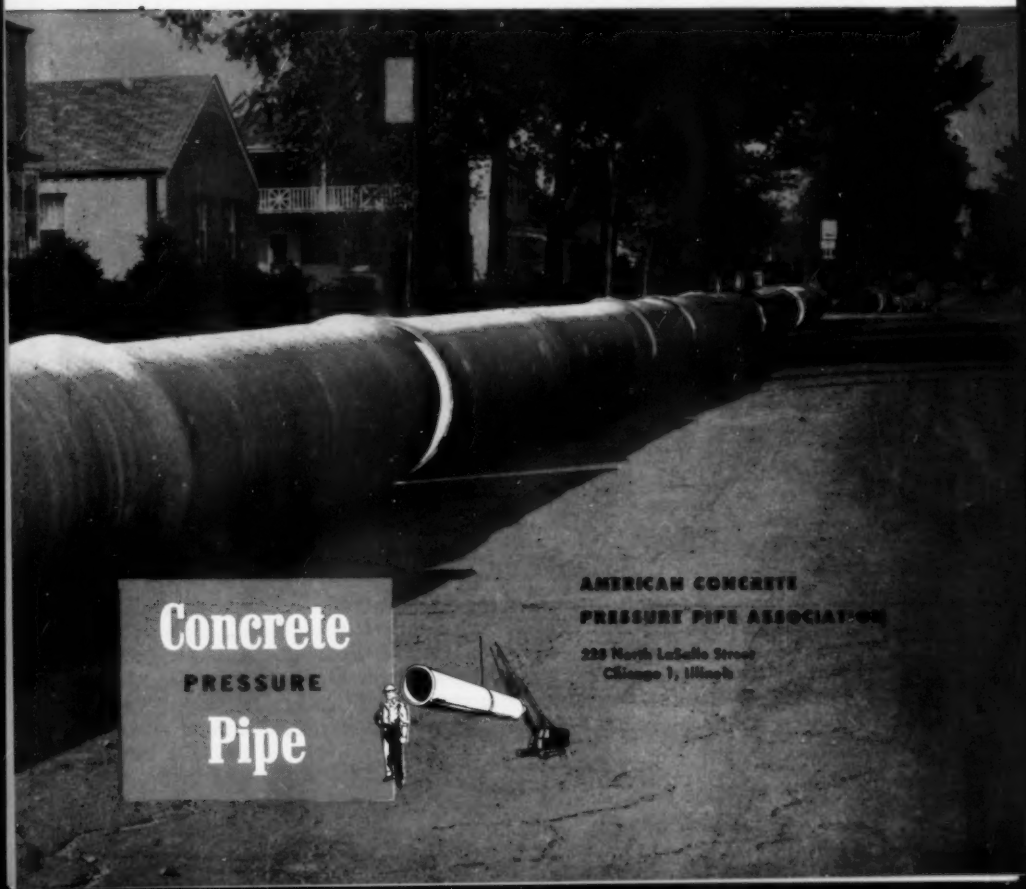
Dependable Concrete Cylinder Pressure Pipe



Concrete Cylinder Pressure Pipe has an unexcelled record for complete reliability. It is your community's best protection against the costly damage claims that can result from water line failure. It is also insurance against the expense and problems usually connected with the repair of water lines particularly in congested locations.

Further, Concrete Cylinder Pressure Pipe can be simply and efficiently tapped under pressure. This makes it easy to establish either service connections for an expanding community or cross connections with other lines in your water distribution system.

WATER FOR GENERATIONS TO COME



(Continued from page 42 P&R)

Service interruptions were held to a minimum during the January floods in Pennsylvania. In complimenting water works operators for a "splendid job of keeping public water supplies in operation," Dr. C. L. Wilbar Jr., Pennsylvania state secretary of health, reported that only one instance of a service interruption had been found. Even then, an emergency supply of safe water was provided and normal service soon restored. During the flood period sanitary engineers of the State Health Dept. maintained round-the-clock checks on public water supplies and worked side by side with utility personnel to assure continuity of service.

Ductile-iron pipe and fittings are now being offered by American Cast Iron Pipe Co., Birmingham, Ala. This relatively new material—first commercially produced in 1949 (see "Ductile Iron—A New Engineering Material for Water Works Construction," by C. T. Haller, October 1952 JOURNAL, p. 912)—is said to combine the corrosion resistance of ordinary cast iron with the mechanical properties of steel. According to American, a major application is in buried water mains subject to extreme loads, unusual shocks, and instability of bedding. Under such conditions, it is claimed, ductile-iron pipe will actually twist and bend without breaking.

Luther L. Smith (center), vice-president and assistant general manager of Smith-Blair, Inc., South San Francisco, Calif., is about to be sworn in as adviser to the director of the Water & Sewerage Industry & Utilities Div. by BDSA Director H. B. McCoy (left). Looking on are Mrs. Smith, Congressman J. Arthur Younger of California, and WSIUD Director Walter L. Picton.

(Continued on page 48 P&R)

Photo courtesy National Water Main Cleaning Co.

Tuberculation did this . . .

IN JUST 8 MONTHS

Eight months before this picture was taken, this main was cleaned, right down to the bare metal. The photograph shows how rapidly tuberculation accomplishes its clogging, flow-reducing work.

This is where Calgon® can help. Threshold Treatment with Calgon* controls corrosion of all types by coating metal surfaces with a tough, water-excluding film. Calgon treatment is particularly effective during and after mechanical main cleaning because of its fast film-forming ability. Protection for freshly scored metal surfaces is quickly built up and easily maintained.

Calgon treatment is inexpensive as well as effective—a few ppm control tuberculation and other corrosion problems as well. A letter or phone call will bring you more information on Calgon. Or, a Calgon engineer, experienced in controlling water problems of all kinds, will be glad to make detailed recommendations on your specific problem.

*Fully licensed under U.S. Patent No. 2,337,856

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DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.
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HAYS

the Quality Line IN WATER SERVICE PRODUCTS

CORPORATION STOPS

One of a complete line of Water Service Products

GENERAL PRODUCTS DIVISION
HAYS MFG. CO.
ERIE, PA.

(Continued from page 46 P&R)

As a matter of fact:

- According to a 1957 low-water datum estimated by the US Lake Survey, the Great Lakes contain a total of 5,442 cu mi of water, of which: Lake Superior contains 2,935 cu mi; Lake Michigan, 1,170; Luke Huron, 849; Lake Ontario, 377; Lake Erie, 110; and Lake St. Clair—yes, we said Lake St. Clair—1.
- In late 1958, New York City had exactly 90,984 fire hydrants.
- The $90,000,000 North Side Filtration Plant now being built in Chicago is the largest single construction job now going on in the United States; its two main buildings will house 98 filters and a 68-mil gal underground filtered-water reservoir. When completed, in approximately 3 years, the plant will supply almost 1 bgd to 3,000,000 residents in Chicago and 26 suburbs.
- At least 8,500,000 US homes still lack a private bath or shower.
- There has not been a single case of typhoid fever traceable to a public water supply in Michigan since 1934.
- Approximately 70 per cent of US swimming pools are located in Los Angeles County.
- There are more electrons in a single raindrop than there are raindrops in all the rain that falls on the United States in an entire year—1.4 sextillion electrons, that is, compared with the number of drops in 1.5 quadrillion gallons of water (Hmmmmm!).

Max Grossman, assistant superintendent of the Atlantic City (N.J.) Water Dept., has resigned to accept an appointment as consulting engineer to the New Jersey Div. of Water Policy & Supply.

(Continued on page 50 P&R)

MORE THAN 2,000 PRESTRESSED CONCRETE WATER TANKS IN SERVICE

In the development of residential and industrial water supply facilities today, no other type of tank offers so many advantages as does the Prestressed Concrete Tank. Modern in engineering and design, proven in service, lowest in cost... prestressed concrete should be considered in any tank planning.

Check these advantages:

- No maintenance required
- Owners never return to other types
- 75% of construction cost spent locally
- Lowest overall cost to community
- Longest service life of any tank

Send for Bulletin T-22

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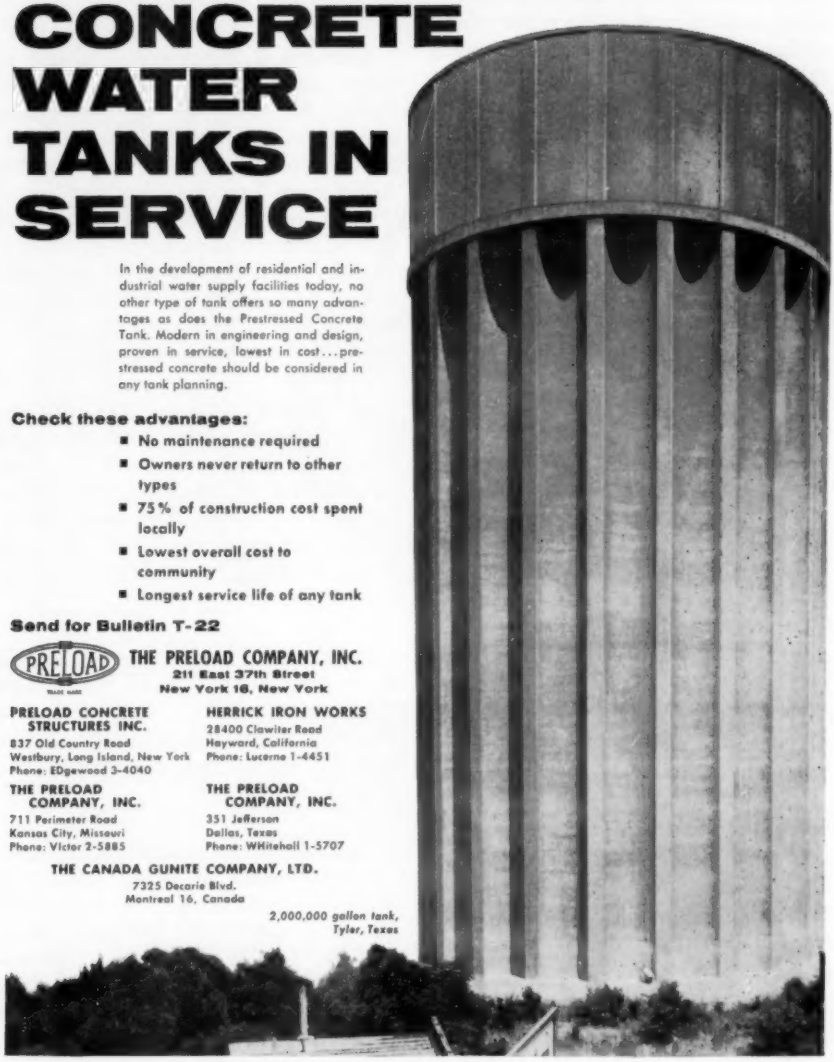
28400 Clawiter Road
Hayward, California
Phone: Lucerne 1-4451

THE PRELOAD COMPANY, INC.
711 Perimeter Road
Kansas City, Missouri
Phone: Victor 2-5885

THE PRELOAD COMPANY, INC.
351 Jefferson
Dallas, Texas
Phone: WHitehall 1-5707

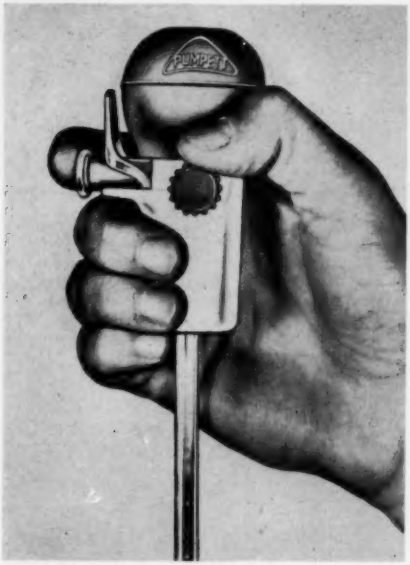
THE CANADA GUNITE COMPANY, LTD.
7325 Decarie Blvd.
Montreal 16, Canada



2,000,000 gallon tank,
Tyler, Texas

(*Continued from page 48 P&R*)

An automatic pipetting device, the "Pumpett," is being offered by Arthur S. LaPine & Co., 6001 S. Knox Ave., Chicago 29, Ill. All sizes of pipets, even microcapillary, can be accommodated, it is claimed, in the rubber-lined, spring-loaded chuck jaws, the clamping action being lever controlled. The device is designed for operation with either hand and can be completely disassembled for cleaning.



"Sticks and stones may hurt my bones, but names will never break me" was the attitude taken by the Tulsa, Okla., water department last month in presenting for payment two checks from apparently unhappy customers, made out:

Pay to the order of the thieves of City Hall, $13.50, for water from a bunch of crooks.

Pay to the order of the crooks of City Hall, $9.75, for a few drops of water and overcharged sewer tax.

These sound like public who ought to be treated as relations.

Leonard B. Dworsky, in charge of water supply and pollution control activities for USPHS in the Pacific Northwest, has been designated departmental representative on the Columbia Basin Inter-Agency Committee, one of the five field branches of the federal Inter-Agency Committee on Water Resources. Mr. Dworsky will be chairman of a Columbia Basin subcommittee now preparing standards for sanitary facilities in recreational areas.

William F. Weimer has been appointed to the newly created position of director of public relations and advertising for Rockwell Mfg. Co., Pittsburgh, Pa. He was formerly advertising manager of Rockwell's Meter & Valve, Municipal & Utilities, and Register divisions.

Infilco Inc. has announced a plan for leasing water, sewage, and waste treatment equipment, with option to purchase. The plan is said to offer financial benefits to both municipal and industrial customers.

William B. Harman has been appointed director of public utilities at Newport News, Va., a post created following the recent consolidation of that city with Warwick, Va. The water system serving both communities was formerly operated by the Newport News Water Works Commission, with Harman as general manager.

(*Continued on page 52 P&R*)

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(Continued from page 50 P&R)

Phosphatation may join fluoridation one of these days as a means of combatting tooth decay if results of research now being conducted by the USPHS continue positive. To date indications in studies of 1,200 children at eight schools in Arizona and New Mexico are that dietary supplementation with harmless mineral phosphates may result in significant reductions in dental caries. The work, carried on in cooperation with the National Institute of Arthritis & Metabolic Diseases, was described by Surgeon-General Leroy E. Burney in a speech before the Chicago Dental Society at the beginning of National Dental Health Week last month. Although he indicated that it will take years to build up significant data, Dr. Burney was optimistic on the outcome of the phosphatation experiments, noting that this procedure could "supplement and extend the protection already available through fluorides and good dental care." Incidentally, it should, perhaps, be explained that phosphatation is not intended as a public water supply procedure; the mineral phosphates are added to bread. This, of course, completes the switch of bread and water from punishment to prophylaxis.

William H. Wisely, ASCE executive secretary, has been reappointed to the New York State Public Health Council and will serve until 1965.

Ludlow Valve Mfg. Co., Troy, N.Y., has named Forbes M. Meston vice-president and treasurer and Frederick W. Wemmerus vice-president in charge of engineering. Mr. Meston was formerly comptroller (and treasurer since 1957), while Mr. Wemmerus held the post of chief engineer.

(Continued on page 108 P&R)

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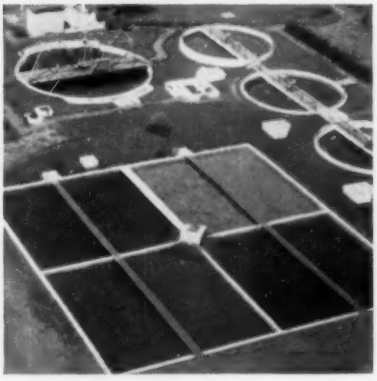

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Key: In the reference to the publication in which the abstracted article appears, **39**:473 (May '47) indicates volume 39, page 473, issue dated May 1947. If the publication is paged by the issue, **39**:5:1 (May '47) indicates volume 39, number 5, page 1, issue dated May 1947. Abbreviations following an abstract indicate that it was taken, by permission, from one of the following periodicals: *BH—Bulletin of Hygiene (Great Britain); CA—Chemical Abstracts; Corr.—Corrosion; IM—Institute of Metals (Great Britain); PHEA—Public Health Engineering Abstracts; SIW—Sewage and Industrial Wastes; WPA—Water Pollution Abstracts (Great Britain).*

CHEMICAL ANALYSIS

The Relation of Chemical Analysis to the Animal and Plant Microorganisms in Water Supplies. F. Lieb; H. Exner; & M. Anschau. Arch. Hyg. (Berlin), **140**:466 ('56). Of 3,050 samples of spring and well waters used for supply which were examd. between '48 and '55, 354 contained visible sediments, which were subjected to microscopic examn. Organisms found were classified as oligosaprobic or nonoligosaprobic. Both types were found in waters which were chemically of required std. of purity for supply.—*WPA*

Analysis of Water Containing *Aedes sollicitans* in Kentucky. E. B. Dixon. J. Tenn. Acad. Sci., **32**(2):147 ('57). 7 complete anals. of low- and high-chloride content waters contg. *A. sollicitans* larvae from pold. oil well and mine sites in Ky. are given. Only 1 sample contained any appreciable amt. of chloride ions, 9,400 ppm. In no instance did 6 complete anals. from Western Coal Field or 15 other samples in that area possess chloride ions in excess of 16 ppm. For comparative purposes complete anal. of water from salt marsh in Fla. is given. All waters examd. had sulfate ions in excess of 1,000 ppm. Possible role of some sulfur compd. as oviposition attractant is suggested.—*PHEA*

Comparative BOD Deterrminations on River Waters. J. Bouquiaux & P. Beaujean. Bull. centre belge etude et document. eaux (Liege), **34**:226 ('56). Expts. were conducted by 2 organizations to det. BOD of same river waters by diln. technique, with and without storage at 4°F. Results show: (1) Storage lowers BOD of samples. (2) Decrease in BOD, important during 1st 3 days of storage only, is 10–30%. (3) Storage temp. (4° and 20°F) is of little importance. (4) All other things being equal detns. in 2 labs. gave different results.—*CA*

Distribution of Boron in Natural Waters. S. Muto. Bull. Chem. Soc. Japan (Tokyo), **29**:532 ('56). Rain and snow of Kiriu Dist. contain 0.1 mg B/l and 2.4 mg Cl/l and that of main stream of Tone R. 0.345 mg B/l and 6.16 mg Cl/l. B and Cl content of springs and tributaries of Tone were detd. also.—*CA*

Chemistry of the Brackish Water of Belgium. M. de Ridder. Biol. Jaarboek Konink. Natuurw. Genoot. "Dodonaea" Ghent (The Hague), **23**:72 ('56). Water analyzed is always shallow; there is thus intimate contact between zone of photosynthesis and that of decompn. Light transmittance is usually slight. Water is brownish because of humic acids. At times it is loaded with water plants which last for several wks. Acidity is high and at times reaches state of supersatn. CaO content is always higher than 100 mg/l.—*CA*

Calcium Content of Waters of the Loire. L. Berthois & E. Bernus. Compt. rend. (Paris), **243**:295 ('56). Ca:Cl ratio is higher in fluvial waters than in sea water. From Mauves to Nantes (Fr.) salt waters of Atlantic do not penetrate, thus Ca content varies from 0.042 to 0.112 g/l and Ca:Cl ratio varies from 1.90 to 5.10. Ca:Cl ratio well off in Grands Charpentiers Estuary is approx. same as in sea water (0.021).—*CA*

Carbonate Equilibrium in Carbon Dioxide Mineral Waters. V. M. Levchenko. Proc. Acad. Sci. U.S.S.R., Sect. Geochem. **108**:65 ('56). This study of carbonate equil. in underground spring shows that H_2O satd. with CO_2 can be maintd. and can migrate under surface without being degasified. Calcns. indicate deg. of CO_2 satn. of H_2O and conditions contributing to H_2O compn. By using theory of ionic activity, eq. for concn. of dissolved CO_2 in natural waters was expressed as $x^3 + Ax^2 + 0.25\ A^2x = 0.25$

(*Continued on page 64 P&R*)

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(*Continued from page 62 P&R*)

$(k'/f_{Ca^{++}}f^2_{HCO^-_3})C_{CO_2}$ where x = concn. of Ca ions, A = excess content of bicarbonate ions, f is activity coeff., and k' is ratio of consts.—*CA*

Carbonate-Calcium Equilibrium in the Water of the Volga. O. A. ALEKIN & N. P. MORICHEVA. Gidrokhim. Materialy (Moscow), **26**:71 ('57). H_2O of Volga R. was analyzed at numerous spots and various times, and anals. are presented in extensive tables. Following conclusions are drawn: upper Volga never satd. with $CaCO_3$ (**I**); during winter unsatn. is most pronounced; during summer it is slightest. Central Volga is only unsatd. with respect to **I** when H_2O contains "aggressive" CO_2 (which remains dissolved long enough at high concn.)—in winter, also during heavy rainfalls; at all other times this part of Volga is satd. or even supersatd. with respect to **I**. Lower Volga is unsatd. in **I** during winter only; during summer there is rather great supersatn. with respect to **I**. Aggressive CO_2 will occur during winter only and will then endanger concrete structures. Width of Volga at any spot bears no direct relation to satn. with respect to **I**, but this satn. will rise during day and drop during night. Carbonate material on bed of Volga is brecciated or clastic **I**; no calcite is found. As amts. of Ca^{++} and HCO_3^- are always rather small in equil. reaction formation of solid **I** will always proceed at low rate.—*CA*

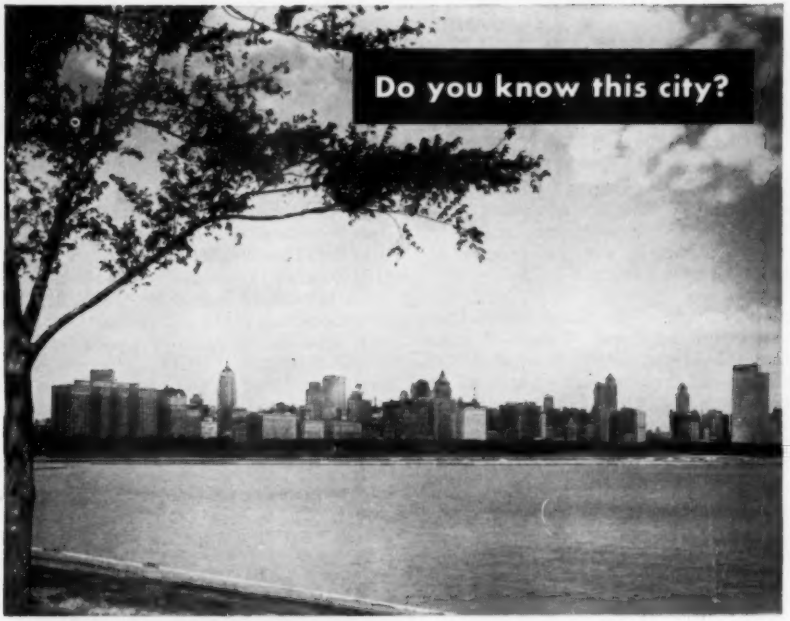
The Influence and Importance of Daily Weather Conditions in the Supply of Chloride, Sulfate, and Other Ions to Fresh Waters From Atmospheric Precipitation. E. GORHAM. Phil. Trans. Roy. Soc. London, Ser. B, **241**:147 ('58). From chem. anals. of samples of daily pptn. in Lake Dist. it appears that local weather conditions play large part in detg. atmospheric supply of ions to natural waters in area. It is evident that atmospheric pptn. is important as source of many of major dissolved ions, especially to bogs, upland tarns on hard volcanic rocks, and to heavily leached soils with wholly organic *mor* humus layers. Ecological signif. of ions dissolved in rain is discussed briefly.—*WPA*

Preliminary Observations on Cobalt and Vitamin B_{12} in Fresh Water. R. J. BENOIT. Limnol. & Oceanogr., **2**:233 ('57). Concns. of cobalt, copper, and iron in vertical series of water samples from Linsley Pond, Conn., were detd. It was found that concns. of cobalt and iron were higher in hypolimnion than in epilimnion but concn. of copper was not. Concns. of cobalt and iron in seston were estd. to be about equal to concns. in normal soils, but copper concn. was much higher. Concn. of Vitamin B_{12} in water was found to be lower than optimum concn. required for some algae in culture. Proportion of tot. cobalt tied up in Vitamin B_{12} in epilimnion was about 10%, and in hypolimnion about 4% or less. This suggests that synthesis of vitamin by blue-green algae in photic zone is more efficient than synthesis by bacteria in hypolimnion.—*WPA*

International Standardization of Drinking Water Quality. H. J. BOORSMA. Ingenieur (Neth.), **69**:G.51 ('57). Author summarizes results of study carried out by the World Health Org. on standardization of drinking water qual. and methods of anal. in European countries. It was agreed that results of chem. anals. should be expressed as me/l, and that hardness should be expressed in me of hardness-producing ions. Stds. proposed for permissible concns. of radioactivity in drinking water are stricter than those of Commn. of Radiological Protection. Recommendations are given for bact. qual. of drinking water and of approved methods of examn. Frequency of sampling and of anal. of water should be based on size of pop. served.—*WPA*

Biological Processes in the Estuarine Environment. The Place of the Estuarine Environment Within the Aqueous Milieu. L. G. M. BAAS-BECKING; E. J. FERGUSON WOOD; & I. R. KAPLAN. Koninkl. Ned. Akad. Wetenschap. (Neth.), Proc. Ser. B, **60**:88, 96 ('57). E_H-pH relations of various natural waters and muds were measured, including estuarine muds (**I**) and waters (**II**), geothermal waters (**III**), evaporates (**IV**), oligotrophic waters as mv derived from sandstones and shales, often iron-contg. (**V**), and limestone milieu waters (**VI**). E_H, as mv, pH ranges for various environments were as follows: **I** 600 to −330, 5.0–9.4; **II** 460–150, 6.5–9.2; **III** 680 to −190, 1.2–8.7; **IV** 580 to −100, 5.7–8.1; **V** 530–50, 4.0–7.4; **VI** 455–100, 5.9–9.0. Among chem. properties influencing environment and contributing to variability of E_H-pH limits were discussed

(*Continued on page 66 P&R*)



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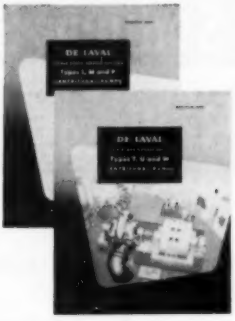

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(*Continued from page 64 P&R*)

buffer system, particularly HCO_3^-–CO_3^{--}, SO_4^{--}, and Fe contents. Practical limits of natural environment were considered to be represented by satd. $Fe_2(SO_4)_3$ soln., E_H 855 mv and pH 0.90, and satd. Na_2CO_3 soln., $E_H + 210$ mv and pH 10.51. Lower E_H limit was considered to result from interplay of sulfide and Fe. Position of various groups of organisms found, comprising sulfate reducing, S-oxidizing, and Fe bacteria and algae, were also discussed.—*CA*

Statistical Study of the Geochemical Characteristics of the Fresh Waters of Japan. I. General Aspect of the Frequency Distribution of the Concentrations of the Constituents in Fresh Waters and Estimations of the Most Prevalent Value for the Fresh Waters of Japan. T. HANYA & F. SAWADA. Geochim. et Cosmochim. Acta (London), 9:249 ('56). Earlier chem. anals. of 627 water samples were examd. statistically. Ca, Mg, sulfate, and SiO_2 are lognormally distributed; but Cl is not, which is believed due to man's environmental interference. Arithmetical mean and geometrical mean (most prevalent concn.) are accurately related by Ahrens' formula and it is shown that for Ca, Mg, sulfate, and SiO_2 arthimetical mean is slightly greater than geometrical mean.—*CA*

The Geochemistry of Mineral Waters of the Northern and Northwestern Parts of the Preshkov Region (Czech.). V. ZYKA & J. JURANEK. Prace ustavu pro maftovy vyzkum (Prague), Ser. E:No. 17–21:81 ('56). Northern and northwestern parts of region are classified into zones having water of $NaHCO_3$ type, $Ca(HCO_3)_2$ type of low mineralization, $Ca(HCO_3)_2$ type of high mineralization, and NaCl type. Based on their primary origin waters of Na bicarbonate type are of petroleum character and at present most of such waters are in stage of metamorphosis. CH_4 occurs in all such waters. CO_2 is of secondary origin and bears no genetic relationship to these waters. However, presence of CO_2 indicates that terr. is in state of high tectonic disruption.

(*Continued on page 68 P&R*)

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(*Continued from page 66 P&R*)

Chem. compns. of majority of waters show considerable infiltration of surface waters. Waters of $Ca(HCO_3)_2$ type of low mineralization do not indicate presence of any useful deposits. They are formed as result of rock leaching by CO_2-charged waters. Occurrence of $Ca(HCO_3)_2$ types of waters of high mineralization is conditioned by presence of waters of $NaHCO_3$ type in sedimentary strata contg. gypsum. Waters of this type likewise are of doubtful signif. as indicators of useful deposits. Waters of NaCl type, characteristic of low-level localities of Tertiary origin, are signif. indicators of presence of underground salt-bearing deposits in upper Tertiary formations.—*CA*

Hydrochemical Regime of the Surface Waters of Takyrs. I. Ya. Degopik. Doklady Akad. Nauk S.S.S.R. (Moscow), **106**: 1083 ('56). Hydrochem. regime of waters which accumulate on surface of takyrs (clayey tracts amid sand) is greatly influenced by presence of algae and lichens. Their metabolic activity is reflected in sharp variations of O and titratable alky. Variations are less pronounced at end of Mar. and beginning of Apr. owing to less intense metabolic activity. During this period there is excessive formation of O. This process, however, continues for brief time only, O being partly absorbed by lower organisms partly dissipated into atmosphere. Reaction is alk., pH is as high as 11, and no free CO_2 is present. In addn. to carbonate there are other ions present which are responsible for alky. These ions are derived from nonvolatile acids, as is evident from potentiometric detn. of total alky., and their relative amt. rises from initial 13 to 75%. Amt. of tot. dissolved and colloidal SiO_2 increases from 11.7 to 35.0 mg/1,000 cc at end of observation period. During this time dissolved fraction increases at expense of colloidal from to 25 to 75%. Although abs. values of tot. alky. increase from 2.02 mg equiv./1,000 cc to 4.85 their relative conts. decrease because of growing mineralization of waters. Tot. alky. is decreased during daytime when photosynthetic activity of algae is at max. That variations are due to algae has been demonstrated with lab. tests. Chem. changes produced by algae present in samples of takyr waters have been compared with those taking place in samples which were treated with $CuSO_4$ to kill organisms. —*CA*

Estimates of the Average Abundance of Copper, Manganese, Lead, Titanium, Nickel, and Chromium in Surface Waters of Maine. K. K. Turekian & M. D. Kleinkopf. Bull. Geol. Soc. Am., **67**:1129 ('56). Semiquant. spectrographic anals. of evapd. residues from water samples taken from 439 streams and lakes are presented. Avg. abundances, as ppb of water, are: Cu 1.16; Mn 0.40; Pb 0.26; Ti 0.20; Ni 0.02; Cr 0.02.—*CA*

The Possible Causes of the Vertical Hydrochemical Zoning of Artesian Waters. O. Ya. Samoilov & D. S. Sokolov. Izvest. Akad. Nauk S.S.S.R. Otdel. Khim. Nauk (Moscow), 257 ('57). Chem. compn. as function of depth of artesian waters does not correspond to their surrounding rocks. Majority of waters changed their characteristics from carbonate to sulfate and chloride salts with their final high concn. This general characteristic can be explained by ion translation movement by jumps, energy of activation of which increases with pressure. Therefore, ion concn. increases with depth, causing corresponding translation movement. Activation energies of different ions encountered in artesian waters have following order: $HCO_3^- > SO_4^{--} > Cl^- > Br^- > I^-$; ion movement veloc. has opposite order, causing mentioned zoning characteristics of artesian waters.—*CA*

Hydrochemistry of the Interstitial Waters of Central Kazakhstan (USSR). E. .V Posokhov. Gidrokhim. Materialy (Moscow), **26**:177 ('57). Rocks of region are made up essentially of feldspar 40–42%, quartz 32–35%, plagioclase 20–25%. Detns. of $Na^+ + K^+$, Mg^{++}, Ca^{++}, Cl^-, SO_4^{--}, HCO_3^-, and CO_3^{--} were made in waters on granite massives of effluents, also for rivers flowing through Devonian and carboniferous strata. All such anals. are tabulated for various times of yr, for periods of 5 yr.—*CA*

Hydrogeochemistry and Genesis of the Hydrogen Sulfide Springs near Gottwaldov (Czech.). V. Zyka. Geol. sbornik (Bratislava), **9**:129 ('58). Chem. anals. of 18 springs are given. Waters of high $NaHCO_3$ content contain much more H_2S, Cl, Br, and I than those with predominant $Ca(HCO_3)_2$, and are believed to be related to petroleum waters.—*CA*

(*Continued on page 70 P&R*)

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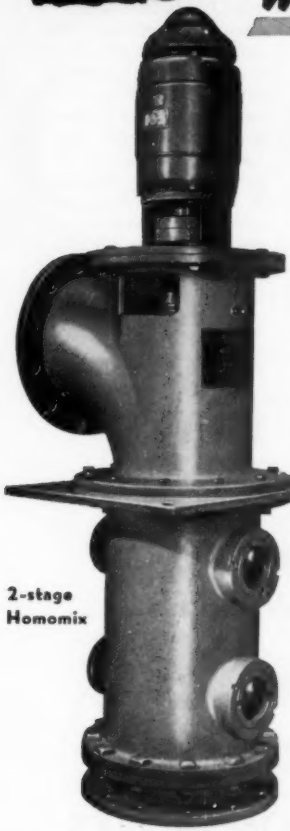

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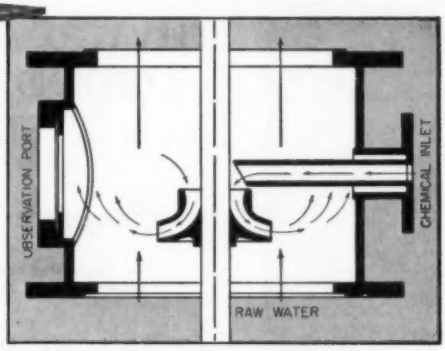

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Chemical and Hydrographic Investigations in the Inner German Bight Area. K. KALLE. Deut. Hydrograph. Z. (Hamburg), **9**:55 ('56). Salinity records show uniform distr. of subsurface water masses during steady meteorological conditions. Low-salinity Elbe R. water forms typical influx pattern. In addn. correlations were established for concns. of albumin, chlorophylls, silicates, and phosphates, and fluorescence phenomena were studied in effort to find further coordination values.—*CA*

The Ionic Composition of Some Lowland Lake Waters From Cheshire, England. E. GORHAM. Limnol. & Oceanogr., **2**:22 ('57). Major dissolved constituents in water from 9 meres in Cheshire were detd.; results are given in tables. Calcium and bicarbonate ions predominate, but these rather concd. waters also contain large amts. of magnesium, sodium, sulfate, and chloride. Chem. compn. of 2 lakes lacking inflow and outflow streams varied considerably, and it appears that their ionic compn. is affected by that of rain. Chemistry of other waters reflects arid conditions which prevailed during deposition of underlying Keuper marls.—*WPA*

Ionic Ratios of Some of the Major Components in River-Diluted Sea Water in Bute and Knight Inlets, British Columbia. M. KIRSCH. J. Fisheries Research Board Can. (Ottawa), **13**:1273 ('56). Concns. of sodium, potassium, and calcium in samples of water taken near heads of 2 inlets in B.C. were detd. by flame photometry. Magnitude of effect on potassium:sodium and calcium :sodium ratios of diln. of sea water by river water was calcd. and compared with exptl. values. In nearly fresh water samples calcium:sodium ratio was higher and potassium:sodium ratio lower than would be expected as result of simple mixing. It is suggested that this may be due to cation exchange of calcium by potassium and magnesium (and possibly sodium) in silt carried by river.—*WPA*

(*Continued on page 72 P&R*)

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The Origin of Iron in the Interstitial Water of Marine Sediments. J. DEBYSER & P.-E. ROUGE. Compt. rend. acad. sci. (Paris), **243**:2111 ('56). Iron occurs in interstitial water of marine sediments in soln. in form of complexes and in colloidal state. Detn. of dissolved and colloidal iron in interstitial water of estuarine mud near La Rochelle (Fr.) showed that concn. of iron was greater than in overlying sea water. Increase in iron in interstitial water is attributed to breakdown of clayey minerals in sediment, which is favored by occurrence of reducing conditions resulting in simultaneous presence in mud of org. matter and sulfate-reducing bacteria. Mechanism of reaction is not known, but it could be result of alteration of silicates by hydrogen sulfide, produced by reduction of sulfate.—*CA*

Iron Bacteria in Mineral Waters of Staraya Russa (USSR). K. I. DEMENT'EV. Mikrobiologiya (Moscow), **27**:210 ('58). Biol. oxidation of Fe is faster than chem. oxidation in Staraya Russa waters. Thread-like sediments of $Fe(OH)_3$, due to *Gallionella*, vary according to environment of the organism. Running water, contg. no Fe compds., will not support iron bacteria. O_2 deficiency also prevents growth.—*CA*

The Chemical Composition of Lake Waters in Halifax County, Nova Scotia. E. GORHAM. Limnol. & Oceanogr., **2**:12 ('57). Results of detn. of chem. compn., optical density, pH value, and specific cond. of water from 23 lakes in healthy spruce forest in Halifax County, N.S. (Can.) during Dec. '55 are given in tables and discussed. Waters were found to be very dil. with low concn. of calcium bicarbonate and high concn. of sodium chloride. 3 main factors affecting chem. compn. are nature of geological substratum, influence of topography as expressed in accumulation of mineral sediments and peat in and around lake basins, and proximity to sea.—*WPA*

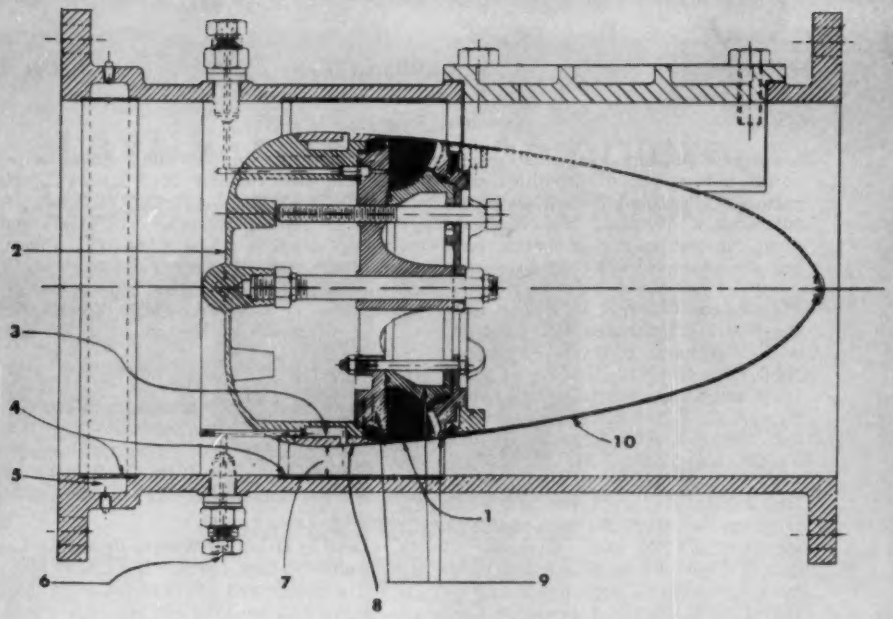
Chemical Study of the Water in the Lake of Neusiedl (Austria). R. HOCK. Prakt. Chem. (Vienna), **8**:163, 166 ('57). Tot. of 750 tests, including 23 complete anals., 107 tests for DO, and 67 for Cl^-, etc., were made. Avg. anal. was (mg/l): Na^+ 417.0, Mg^{++} 136.2, Ca^{++} 16.0, Al^{+++} 1.4, Fe^{++} 0.6, NH^+ 0.4, tot. cations 571.6; SO_4^{--} 572.8, HCO_3^- 488.0, Cl^- 227.0, CO_3^{--} 120.0, tot. anions 1407.8; SiO_2 9.5; tot. residue on evapn. 1,826, after ignition 1,104; tot. hardness 336 (as CoO); sp gr at 20°F. 1.0024; pH 845. This is mineral water. It is not necessarily fit for human consumption.—*CA*

Free Sugars in Filtered Water. J. R. VALLENTYNE & J. R. WHITTAKER. Science, **124**:1026 ('56). Water from 2 Ont. (Can.) lakes was filtered through Milipore HA ultrafilters, deionized with Amberlite 1R-4B and IR-120 resins, and evapd. to dryness at temps. less than 45°F. Residue was chromatographed on paper and amt. of sugar present estd. by comparing spot areas with those of known sugars sprayed with benzidine and orcinol reagents. Sucrose (2–10 mg/cu m) and glucose (1–5 mg/cu m) were only sugars detected.—*CA*

The Chemical Composition of Some Waters From Lowland Lakes in Shropshire, England. E. GORHAM. Tellus (Stockholm), **9**:174 ('57). Anals. are presented for pH, Na, K, Ca, Mg, HCO_3, Cl, SO_4, NO_3, PO_4 and SiO_2 in surface waters from 8 small Shropshire lakes which are subject to dense water blooms of blue-green algae. Samples were taken in Nov. '54 and Jun. '55. It appears likely that chemistry of waters reflects increasing alteration of rainwater compn. by soln. of products of rock and soil weathering, chiefly calcium bicarbonate. Magnesium was only major ion observed to vary greatly with season of sampling. Potassium was anomalous in being more abundant in dil. waters where it acctd. for unusually high proportion of tot. salts. Attempt has been made to relate chem. compn. of various waters to local geological and physiographical variations.—*PHEA*

The Lignin Fraction of Marine Sediments. R. G. BADER. Deep-Sea Research, **4**:15 ('56). Anal. of 31 surface samples of marine sediments from Gulf of Me. and 26 samples from 2 cores collected in Puget Sound (Wash.) showed that lignin is very variable fraction of org. matter in sediments. In 2 Puget sediment cores, loss of non-ligninous carbon was about 6 times that of lignin carbon. Apparently lignin is extremely stable in marine environment. Knowledge of concn. of lignin in sediments might be useful in studies of sedimentation,

(*Continued on page 74 P&R*)



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(*Continued from page 72 P&R*)

but it must be detd. whether it is dependent on or independent of deposition of inorg. particles. Possible effects of lignin on carbon-nitrogen relations and base-exchange capac. of org. matter in marine sediments are also discussed.—*WPA*

Magnesium Chloride in Saline Lakes of the North Kazakhstan. A. B. Bekturov; A. I. Mun; & R. S. Darer. Vestnik Akad. Nauk Kazakh. S.S.R. (USSR), **14**:5:68 ('58). Main components of saline water of Zhalauly, Kyzylkak, and Teke lakes were studied. Saline water of Zhalauly lake contains $Ca(HCO_3)_2$, $CaSO_4$, $MgSO_4$, $MgCl_2$, and NaCl. Lake belongs to sulfate type, with 1.1–1.2% sulfate ions. Resource of $MgCl_2$ calcd. to be 10,000,000 tons, and of NaCl approx. 25,000,000 tons. Kyzylkak lake is quite shallow, 1.1 m (3.6 ft) deep, and its main components are NaCl and $MgCl_2$ (more than 4%). Approx. resources of salts are 4,400,000 tons $MgCl_2$, 1,300,000 tons $MgSO_4$, and 23,500,000 tons NaCl. Area of calcn. was 155 sq km (60 sq mi) with avg. depth of 0.6 m (1.96 ft). Saline water of Teke lake contains $MgSO_4$, $MgCl_2$, NaCl, $CaSO_4$, $Mg(HCO_3)_2$, and $Ca(HCO_3)_2$. Area of L. Teke is 220 sq km (78 sq mi) and its avg. depth is 0.5 m (1.64 ft). Concn. of $MgCl_2$ is 8%. Approx. amt. of $MgCl_2$ is 10,000,000 tons. Abundant resources of $MgCl_2$ in all 3 lakes make possible future development of Mg industry in Kazakh S.S.R.—*CA*

The Roisdorf Mineral Waters. E. Schenck. Decheniana (W.Ger.), **108**:197 ('56). Chem. anal. shows that compn. has changed little since 1824; $NaHCO_3$ and NaCl are predominant dissolved constituents.—*CA*

Lead in Drinking Waters From the Lower Loire Valley (Fr.). Lasausse & Abry. Rev. pathol. gen. physiol. clin. (Fr.), **56**:1920 ('56). As much as 0.98 mg Pb/l was found in waters with low pH (3.6); even waters with pH more than 7 may reveal as much as 0.04 mg/l.—*CA*

(*Continued on page 78 P&R*)

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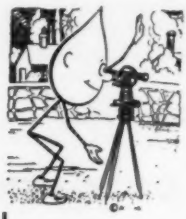

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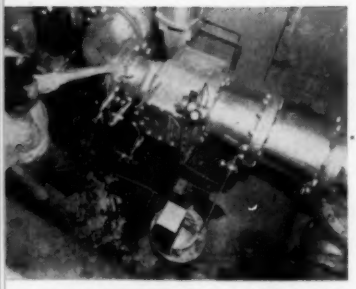

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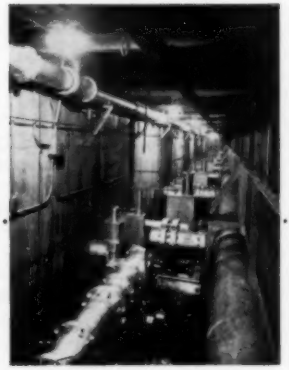

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(*Continued from page 74 P&R*)

The Mineral Spring Waters of Furth, Bavaria. F. BIRZER. Geol. Bl. Nordost-Bayern (W.Ger.), **6**:106 ('56). Many anals. are given, including some detns. of Br, I, Sr, Li, B, and As. Waters mostly have very high contents of Ca, chloride, and sulfate. —*CA*

Microelements in the Mineral Waters of the Southern Slopes of the Soviet Carpathians. A. E. BABINETS & N. I. RAD'KO. Geol. Zhur., Akad. Nauk Ukrain. R.S.R., Inst. Geol. Nauk (USSR), **16**:2:21 ('56). Spectrum anals. of principal mineral waters of trans-Carpathian southern slope showed that largest no. of elements present in trace amts. were found to exist in carbonated waters; all of these waters contained Ba, most of them Sr, Ni, F, B, and I. Cu, Pb, and Ag were found frequently, although only in small amts. Co and Zn were less frequently found, and V, Be, and Zr only very rarely. H_2S-contg. waters, especially highly mineralized NaCl-contg. waters, are low in microelement content. Most of microelements were traced to sedimentary or igneous surrounding rocks. High I content is attributed to their deposition from sea water. Travertine rocks of carbonated water sources were investigated.—*CA*

The Composition of Bottom Muds in Relation to the Phosphate Cycle in the Inshore Waters of the Malabar Coast. G. SESHAPPA & R. JAYARAMAN. Proc. Indian Acad. Sci. (India), **43B**:288 ('56). Temp., pH, silt colloidal matter, moisture, and PO_4 content of bottom mud collected along Malabar Coast (W.India) show seasonal variations; values are generally low for all factors during monsoon mos. Bottom muds contain large quants. of PO_4 in nonmonsoon mos.; during monsoons there is rapid release of PO_4 into overlying column of water. Factors affecting monsoon release of PO_4 from muds are discussed.—*CA*

The Determination and Occurrence of Nickel in Sea Water, Marine Organisms, and Sediments. T. LAEVASTU & T. G. THOMPSON. Conseil permanent intern. exploration mer (Copenhagen), **21**:2:125 ('56). Methods of anal. for Ni in sea water, particulate material, and marine organisms were investigated and modified. More satisfactory recovery of Ni was obtained by use of collectors already present in sea water and use of Na_2CO_3 as precipitant. Wet combustion was preferable to ash method in prelim. treatment of marine organisms for Ni anal., and H_2O samples should be treated immediately after sampling. Sea water from Puget Sound (Wash.) contained 0.034 γ g-atomic Ni/kg in soln. and 0.005 γ g-atomic Ni as particulate. Fresh water contained less sol. Ni. Plankton contained twice amt. of Ni as higher marine plants and 10 times amt. found in fish and molluscs examd. Plankton collected in euphotic layers contained twice concn. as samples from aphotic layers. Plants and animals conc. Ni in their calcareous skeletons. Concn. of Ni in sediments increased as depth of H_2O and distance from shore increased. Ni is halmirolyzed from shallow H_2O sediments and enriched in deep sea deposits by scavengers. —*CA*

The Physical Oceanography of Bute Inlet, British Columbia. S. TABATA & G. L. PICKARD. J. Fisheries Research Board Can. (Ottawa), **14**:487 ('57). Surveys have been made of distr. of salinity, temp. and oxygen in Bute Inlet, B.C. (Can.) between Aug. '50 and Jul. '53. In general, surface salinity increases to seaward and with depth during all seasons, but seasonal variations in salinity occur as result of periods of low and high river flow. Below 60 ft no obvious salinity cycle occurs. During both winter and summer, surface temp. generally increases to seaward. During winter temp. gradient in upper layers increases vertically downwards, and in summer it decreases vertically downwards. Seasonal temp. variation is observed to depth of 150 ft. Main factors affecting sea temp. are insolation and cold river runoff. Concn. of DO is usually high in surface layer. Waters at greater depths are not stagnant as they contain 40% of oxygen satn. —*WPA*

Distribution of Phosphorus in Great Pond, Massachusetts. E. M. HULBURT. J. Marine Research (Sears Foundation), **15**:181 ('56). In '50 detns. were made of inorg. phosphate and total phosphorus in Great Pond, small estuary near Falmouth, Mass. It was found that, except in deeper water during summer, concn. of inorg. phosphate was less in Great Pond than in its sources of fresh and salt waters. In summer, particularly in deeper water, concn. of tot. phosphorus was greater in pond than in Vineyard Sound or Coona-

(*Continued on page 80 P&R*)

How to Choose Waterstop for optimum performance in concrete joints

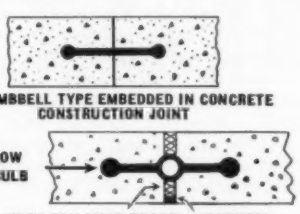
Basic Design And Resilience Most Important Factors

The principal function of waterstop is to keep concrete joints watertight where hydrostatic water pressure is present. To be effective, and to perform its function under widely varying conditions, the waterstop must:

1. **Be designed in such a way that it will maintain a "pressure seal" when the joint is opened up or compressed, or when hydrostatic pressure is exerted against it.**

2. **Be made of a material that is inherently stable and resilient . . . that will retain its resiliency and strength under wide ranges of temperature.**

There is general agreement by many governmental and private specifying authorities, after years of testing and actual installation, that the dumbbell design of waterstop (below) is mechanically superior to any which has been developed to date. The design provides a self-sealing action, because as the concrete contracts and the joint opens up, the outer edges of the dumbbell bulbs become more tightly engaged with the concrete, insuring a tighter seal as the tension increases, due to movement either in the joint or increasing water pressure on one side of the joint. In effect, the greater the longitudinal pull or pressure on one side, the more tightly the dumbbell ends are pulled and squeezed against the concrete. The simpler dumbbell design of the rubber waterstop allows full strength and contact with the concrete surrounding the waterstop. The larger design also provides for maximum strength to resist higher pressures on the web of the waterstop across the joint opening.



Rubber and vinyl are the most commonly used waterstop materials. For the majority of applications, rubber is the most satisfactory material. Being a thermosetting material, rubber is more resilient and "live" . . . will maintain a constant pull against the retaining edges (bulbs) as the joint opens up or water pressure increases. Vinyl is a thermoplastic compound and tends to take a "set" after it has been stretched, will float in the joint cavity, and have less resistance to the passage of water. When higher temperatures are present, such as in oil storage tanks, where oil is kept at temperatures around 150°F., the vinyl material, unless specifications are rigidly written, will soften and lose strength, causing a failure of the waterstop.

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The Union is made in the same cross-section, and from the same material as the waterstop. It is hollow, except for a solid web at the center. After adhesive is applied to the waterstop ends, they are inserted in the Union and pushed against the centering web. The splice is then clamped together until the adhesive has set. This completes the splice.

Dumbbell type rubber and neoprene waterstop are fully described in a special Waterstop Circular available from Servicised Products Corporation upon request. The Union and an interesting new development, Split Type, are also illustrated and described in the circular. Write for it today.

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(*Continued from page 78 P&R*)

messett R., but during remainder of yr concns. of tot. phosphorus were similar in sound, pond, and river. As much as 92% of tot. phosphorus within pond was org. Accumulation of phosphorus in summer is attributed to increased photosynthesis, products of which settle from surface to deeper waters which return them up-pond in countercurrent.—*WPA*

Preliminary Observations on the Total Phosphorus Content of the Inshore Waters of the Malabar Coast Off Calicut (India). S. V. Suryanarayana Rao. Proc. Indian Acad. Sci. (India), **45B**:77 ('57). Tot. P contents of inshore waters of Malabar Coast (India) were relatively high, ranging from 0.44 to 9.46 γ atoms/l. Only small part of P was in sol. inorg. form, 8–37%; most was in bound and org. forms. Significantly higher P values were found during monsoon season. It is felt that great agitation of water column during this season releases P from bottom muds. Large-scale mortality of bottom fauna might also cause this increase. High P values are in keeping with great fertility of this area.—*CA*

Tracer Study of the Phosphorus Cycle in Lake Water. F. H. Rigler. Ecology, **37**: 550 ('56). Results are given of tracer study which supplements information concerning circulation of phosphate in L. Toussaint, small acid-bog lake near Chalk R., Ont. (Can.). P^{32} was used as tracer to demonstrate movements of naturally occurring P. Of tot. P^{32} added to surface 77% was lost from water and plankton in 4 wks., but only 2% was lost through outlet and 3% to mud. It was concluded that there was turnover of mobile P of epilimnion with P of littoral organisms. Turnover time was 3.5 days. Several days after addn. of P^{32} to lake 50% had passed into fraction of plankton. (Turnover time and % of P^{32} passing into fraction of plankton agree with previous investigations.) Turnover time of inorg. phosphate was approx. 5 min. In lab. expts. with aquatic bacteria it was found that inorg. phosphate was rapidly used from lake water but when sterile water was stored there was no loss of phosphate from soln. Turnover of phosphate under natural conditions appeared to be caused by bacteria. It was noted that aquatic bacteria may compete with algae for inorg. phosphate. Methods and equip. are described.—*CA*

Some Peculiarities in the Photoluminescent Analysis of Water. I. G. Popov. Gigiena i Sanit. (Moscow), **23**:5:21 ('58). For natural waters and peptone solns. photoluminescence is not affected by temp. or concn. of sea salt, but pH values above or below 5–8.5 reduce it. Pure NaCl is not meant.—*CA*

The Decomposition Products of Radon in the Water From the Hot Springs of Gastein. K. Aurand; W. Jacobi; & A. Schraub. Osterr. Akad. Wiss. Math.-naturw. Kl., Sitzber. Abt. II (Vienna), **165**: 1–4:133 ('56). Short-lived products occur in concns. of less than 20% of equil. in waters of natural spring mouth, but they occur in equil. concns. in waters stored in tanks. Measurements on probes along water line from Bad Gastein to Bad Hofgastein (Austria) showed that Rn-contg. water constantly loses decompn. products when it flows through narrow cross-sections. Similar mechanism must occur within rocks below surface so that satn. of water with Rn must occur in low regions. Analogously, water used in bathing contains less than equil. amts. of Rn decompn. products.—*CA*

Chemical Composition of Rain From Rosscahill in County Galway (Ire.). E. Gorham. Irish Naturalists' J. (N.Ire.), 12:122 ('57). Rainwater collected in Galway and Lake Dist. of Ire., resp., showed following avg. compn. (ppm): Na 3.2, 1.9; K 0.5, 0.2; Ca 1.7, 0.3; Mg 0.5, 0.2; HCO_3^- 5.4, 0.0; Cl^- 4.5, 3.3; SO_4^{--} 2.9, 3.2; NO_3^- 0.05, <0.02.—*CA*

The Chemical Characteristics of the Waters of the Upper Reaches of the Rivers Tobol and Ayat (Kazakhstan, W. Siberia). I. S. Sosedov & T. I. Slutskaya. Izvest. Akad. Nauk Kazakh. S.S.R., Ser. Energet. (USSR), No. 11:3 ('56). Results of elaborate mineral survey of waters of Tobol R. and of its main tributaries Ayat and Ui involving 160 samplings made in both wet and dry seasons are tabulated and plotted. Chem. characteristics are extremely variable. At village Kozyrevka on Tobol, at time of spring floods with dischg. of 426 cu m/sec, sum of ionic components Ca^{++}, Mg^{++}, $Na^+ + K^+$, HCO_3^-, SO_4^{--}, and Cl^- is at min. of 147 mg/l; in late summer with flow of 0.16 cu m/sec it goes to max. of 1300 mg/l.—*CA*

(*Continued on page 82 P&R*)

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(*Continued from page 80 P&R*)

Sedimentation and Material Content in Lake Turler. E. A. THOMAS. Schweiz. Ver. Gas- u. Wasserfach., Monatsbul. (Switz.), **36**:297 ('56). Previous investigations in L. Turler showed scarcity of oxygen and production of hydrogen in deeper layers of 21-m (69 ft) deep lake. No mixing of deep water with surface water takes place. Author describes monthly examns. of sediment collected at depth of 20 m (66 ft). Results of phys. and chem. examn. of collected sediment are given in figs. and discussed. Examns. were also made of water of tributary streams and of outlet. Calcns. are made of retention of substances in lake water, of return to water, by soln., of phosphorus and nitrogen compds. after sedimentation, and of relation between oxygen demand of sediment and of lake water. Judged by values for contents of nitrate and phosphate L. Turler could be classified as oligo- or mesotrophic but sedimentation values correspond more closely to those of eutrophic lakes. It is suggested that in small lakes influence of banks and effects of temp. are more intense than in larger bodies of water and that condition of small lake cannot be judged on same stds. as are used for classification of large lakes.—*WPA*

Chemical and Physicochemical Analysis of Spring Water From Serrapetrona (It.) Called "Fonte della Concia," "Tanning Water." F. VASCELLARI. Boll. lab. chim. provinciali (Bologna), **7**:63 ('56). Physicochem. constituents and chem. anal. are reported indicating that "Fonte della Concia" is medium-mineral water contg. HCO_3^-, SO_4^{--}, Ca^{++}, and Mg^{++}.—*CA*

Oxidation-Reduction Processes and the Gas Composition of the Tiflis (USSR) Hot Springs. M. V. MZAREULISHVILI. Soobschcheniya Akad. Nauk Gruzin. S.S.R. (USSR), **18**:687 ('57). Thermal springs at Tiflis contain both dissolved and undissolved gases. Chief gases are N and CH_4. Springs are subdivided into 2 groups: Cl-Na-Ca waters, which contain considerable CH_4 but little N; Cl-HCO_3^--Na and SO_4-Cl-Na waters, where CH_4 and N occur in almost same amts. Investigation of reducing and oxidizing processes in waters showed that H_2S is principal reducing agent present.—*CA*

Silica in Hot-Spring Waters. D. E. WHITE; W. W. BRANNOCK; & K. J. MURATA. Geochim. et Cosmochim. Acta (London), **10**:27 ('56). Study of silica in hot-spring waters and in some cold waters by means of colorimetric NH_4 molybdate method of anal. indicates that nearly all silica of hot springs is in monomeric form. Soly. equil. exists between dissolved (monomeric) and amorphous silica. For hot springs studied soly. is about 315 ppm at 90°F and 110 ppm at 25°F. (These results are similar to a previous investigation.) Many waters are supersatd. with respect to amorphous silica because monomeric silica polymerizes so slowly to colloidal silica. Rate of polymerization is influenced by pH, temp., deg. of supersatn., presence of previously formed colloidal and gelatinous silica, and contact with opal and other substances. Supersatd. acid waters and alk. waters with less than 100% supersatn. tend to remain supersatd. almost indefinitely. Pptn. of colloidal silica is facilitated by high temp. and contact with opal. Many ground waters, including connate and some thermal spring waters, are much less than satd. with respect to amorphous silica, probably because low-soly. quartz and chalcedony have pptd. Quartz is believed to form by deposition of monomeric molecules. It is favored by relatively high temps., slow rate of pptn., and low degree of supersatn. Chalcedony is probably deposited when deg. of supersatn. is moderately high and rate of deposition is relatively fast. Ranges of temp. over which quartz and chalcedony deposit overlap, but quartz is favored by high temp. if other factors are equal. Opal is favored by relatively low temp. and rapid pptn. rate. Opal has probably been deposited at temps. as high as 140°F, but it is unstable and is slowly converted to chalcedony or quartz. Water that is satd. with respect to opal is highly supersatd. with respect to quartz. Opal is probably formed from monomeric, or more probably, smaller polymeric molecules of silica, retaining some of their water content. Evidence is lacking for direct conversion of gelatinous silica to opal. Some differences in soly. probably exist between amorphous opal and opal that shows X-ray patterns like that of cristobalite. It is suggested that clay minerals form by combination of monomeric silica and comparable forms of monomeric alumina which must have very low soly. in waters

(*Continued on page 84 P&R*)

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(*Continued from page 82 P&R*)

within pH range of 5–9. Proposed reaction, dissolved alumina + dissolved silica ⇌ clay, is ordinarily displaced strongly to right in hydrothermal alteration and in ordinary soil formation because of abundance and relatively high soly. of silica. With removal of free silica, aided by tropical rainfall and temps., reaction may be displaced to left by soln. and removal of silica from system. Alumina remains as bauxite because of its very low soly.—*CA*

Mechanism of Silicate Scale Formation. M. S. Ostrikov & V. G. Gleim. Zhur. Priklad. Khim. (Moscow), **30**:508 ('57). Kaolin or native clay boiled in distd. or river water formed silicic acid (**I**). Concn. of **I** increased with duration of boiling and concn. of suspension. On cooling and standing for 18 hr at room temp. **I** recombined (disappeared); on repeated boiling **I** formed again. With 0.15–0.80% kaolin suspensions amt. of **I** formed was reduced to 0 on cooling, whereas with 1.5% suspensions appreciable proportions of **I** remained. In suspensions of 0.5% kaolin contg. 100 mg NaOH and 100 mg Na_2CO_3/l or 100 mg of NaOH/l **I** on boiling increased more rapidly with time than in suspensions without alkali. But on cooling, concn. of **I** did not decrease to 0. If scale formation in boiler was due to pptn. of insol. silicates (Mg) or to formation of semicolloidal micelles which adhered to hot surfaces then addn. of substance which adsorbed **I** should prevent scale formation. Addn. of $MgSO_4$ and $Mg(OH)_2$ affected formation of **I** very little; addn. of $Al(OH)_3$ reduced concn. of **I** appreciably. $Fe(OH)_3$ was most effective: with 0.2% $Fe(OH)_3$ formation of **I** was slight and with 0.4% none. Suspensions with $Fe(OH)_3$ boiled in quartz tubes formed more of **I** than when boiled in steel tubes but difference decreased to zero as $Fe(OH)_3$ increased to 0.4%. At room temp., however, $Al(OH)_3$ adsorbed more of **I** from Na silicate than $Fe(OH)_3$: 0.1% of the former adsorbed practically all of **I** in 42 hr. In 115 hr adsorption capac. of 2 hydroxides was about same.—*CA*

(*Continued on page 86 P&R*)

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(*Continued from page 84 P&R*)

The Spring Waters in the Toge Landcreep Area, Osaka Prefecture (Jap.). Y. ITIHARA. J. Geol. Soc. Japan (Tokyo), **62**: 244 ('56). Chem. compn. of 2 spring waters in this area was studied with special reference to relation of water and water-bearing materials, which are largely composed of granite-gneiss boulders, granitic sands, and weathered andesites. Content of Ca^{++} in spring waters is dominated by leaching from exchangeable cations of montmorillonite which is main constituent of weathered andesite, and content of alkali metals is most affected by soln. of granitic material. Exchangeable Mg^{++} of clay mineral is brought into spring waters by leaching; K^{+} is fixed by clay mineral so that its content tends to decrease in spring waters.—*CA*

Fluorine in Thermal Springs. A. A. ALEKSEEV. Geokhimiya (Moscow), **4**:58 ('56). According to observations migration of fluorine within limits of geochem. zones of crust of weathering can be characterized by following data. Data presented characterize zone of oxidation as zone impoverished in F-contg. minerals. In aq. solns. of zone of aeration F content is 0.01–0.10 mg/l. In zone of cementation circulating interstitial waters increase mineralization, thus leading to increased F content. In zone of primary ores there is increase of total mineralization and increase of F content. Acratotherms are defined as hot, slightly mineralized interstitial waters with temp. reaching 92–100°F, and which rise from considerable depths. Chem. compn. of acratotherms is very different from that of waters circulating in different geochem. zones. Most typical acratotherms show the following characteristics: (1) low content of mineralization; (2) high alky.; (3) Na^{+} predominates in cations; (4) in anions SiO_3^{--}, $HSiO^{-}_3$, OH^{-}, CO_3^{--}, and HCO_3^{-} tot. 90 me%; (5) in anions F accounts for 5% of mineralization; (6) silicic acids in all their forms amt. to 50% by wt. of mineralization; (7) Cl^{-} content in individual acratotherms is $\frac{1}{3}$ to $\frac{1}{4}$ F^{-} content and amts. to 1.6–3.0 mg/l; (8) content of Ca^{++} amts. to tot. of 1–3 mg/l. In acratotherms which have tot. mineralization of 100–200 mg/l activity coeff. of uni- and bivalent ions practically approaches unity. Following scheme of formation of acratotherms may be given: (1) in regions of young Alpine folding continuously occurring metamorphism of rocks is accompanied by evolution of gases and (2) in cases where among products of exhalation there is little or no CO and CO_2, but many fluoride compds., compds. react with rocks and with water.—*CA*

Particularities of the Fumarole Formations of Hot Springs in Southern Kamchatka (Siberia). G. A. GONSOVSKAYA. Doklady Akad. Nauk S.S.S.R. (Moscow), **113**:172 ('57). In area of active volcanoes Mutnovsk, Koshelevsk, and Il'insk hot springs are abundant with variable chem. characteristics of their waters and variable temps. Variations have characteristic interrelation to distances from volcanic activity centers. For Koshelevsk volcano especially there is zone of highly active fumaroles near craters and on their slopes and another zone with typical extinction phenomena. 1st group have temps. of 95–100°F, vapors are rich in B_2O_3 (80–100 mg/l H_2O). F^{-} and NH_4^{+} are not only characteristic for this active group, they also may have been introduced into waters by leaching from country rock horizons of older volcanic activities. This can also explain their high contents in H_2SiO_3 which bring about sedimentation of opal. Usually such active hot springs are rich in Fe, Al, Na_2SO_4, and NH_4 salts, and have acidic character (pH = 1.7–4.5). Springs of 2nd extinguishing group have max. temps. of only 62°F, but contain particularly large amts. of free CO_2 (as much as 700 mg/l). Characteristic are following (avg.) ratios: Na/Cl = 22 for group **I**, 2.5 for group **II**; $Cl/SO_4 = 0.02$ (**I**), 0.6 (**II**); Cl/B = 0.3 (**I**), 7.2 (**II**). In spite of clear interrelation with volcanic activity centers, principal supply of H_2O to springs is from rainfall and deep-circulating ground waters. In their abs. vol. the contributions of volcanic exhalations to springs are relatively subordinate, and atmospheric gases make up most of gas contents of fumarolic volatiles.—*CA*

Using Isotopes in Studies of Sulfate-Reduction Activity in Lake Belovod. M. V. IVANOV. Mikrobiologiya (Moscow), **25**:305 ('56). Fermentation tests with $Na_2S^{35}O_4$ showed that sulfate reduction in L. Belovod waters was absent or very slow, but in bottom muds rate of daily H_2S formation was 0.067 mg/l in littoral muds and 0.12 mg/l in deep-water muds.—*CA*

(*Continued on page 88 P&R*)

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(*Continued from page 86 P&R*)

Determination of Thiosulfates in the Mud Waters of the Sediments in the Black Sea. I. I. VOLKOV & E. A. OSTROUMOV. Doklady Akad. Nauk S.S.S.R. (Moscow), **114**:853 ('57). Well-known S content of ground sediments of Black Sea is characterized by strongly reducing conditions, chiefly content of free H_2S, while fresh-water sediments never show H_2S. Samples taken from depths between 108 and 2,075 m (350 and 6,800 ft) decidedly contain sol. thiosulfates in presence of hydrotroilite. Anal. detn. was performed by titrimetric (iodometric) method of Kurtenacker and Bittner. There is very distinct increase in $S_2O_3^{--}$ contents of water in clayish muds from 0.56 to 6.61 mg/l with increasing depths. Anion SO_3^{--} is practically absent, at least in limits of anal. errors. Fresh-water sediments never contain thiosulfates.—*CA*

Vanadium in the Water of the Seine and in the Atmospheric Dust in Paris. A. MORETTE. Ann. Pharm. Franc. (Paris), **15**: 209 ('57). V is liberated in combustion of heavy petroleum oils. Its widespread occurrence in atmospheric dust is ascribed to exhaust of Diesel motors. However, since V is found generally in minerals and soil its presence in small quant. in river water is considered as normal occurrence.—*PHEA*

Relations Between the Chemistry of Minnesota Surface Waters and Wildlife Management. J. B. MOYLE. J. Wildlife Management, **20**:303 ('56). Range of constituents found in 1,546 anals. of surface waters of Minn. were: tot. alky., 6.3–537.5 ppm; sulfate ion, 0.0–1210.0 ppm; chloride ion, 0.0–113.0 ppm; tot. P, 0.002–1.6 ppm; and tot. N, 0.06–5.9 ppm.—*CA*

CHEMICAL ANALYSIS

Chromatographic Identification and Determination of Organic Acids in Water. H. F. MUELLER; T. E. LARSON; & W. J. LENNARZ. Anal. Chem., **30**:41 ('58). Analysts in field of water and water chemistry have for many yr faced problem of quant. sepn. and identification of small concns. of org. compds. in water. Adsorption chromatography can quantitatively separate various acids for later identification. This technique provides new method for sepn. of anionic synthetic detergents from anal. interferences. It may be considered as research tool, where BOD and chem. oxygen demand detns. are inadequate, which may be further developed for study of addnl. metabolic products of biol. purif. processes. Neither "catch-all" method can approach sensitivity and accuracy of chromatography.—*PHEA*

Flame Photometry in Analysis of Natural Waters. III. Determination of Calcium. P. VALORI; M. TALENTI; & F. SAVOINI. Ricerca Sci. (Rome), **27**:1901 ('57). Interference of various ions (Na^+, K^+, Li^+, Mg^{2+}, Cl^-, SO_4^{2-}) in flame photometric detn. of Ca is circumvented by procedure comprising addn. of spectrochem. buffer contg. high concn. of interfering ions and measurement of difference in emission intensities at Ca line (4227A) and at nearby wavelength (4200A) not influenced by Ca. 1 ppm of Ca may thereby be detd.—*PHEA*

Determining Residual Chlorine Compounds in Water Using Diethyl-*p*-Phenylenediamine. A. T. PALIN. Wtr. & Wtr. Eng. (Br.), **62**:30 ('58). For free Cl_2, add approx. 0.5 g diethyl-*p*-phenylenediamine powder to 100-ml sample, mix rapidly, titrate with ferrous ammonium sulfate soln. For monochloramine, add 1 small crystal of KI, continue titration. For dichloramine, add approx. 1 g KI, mix, let stand 2 min, continue titration. Same method can be adapted to colorimetric detn.—*CA*

Comparative Results of the Determination of Water Hardness by Complexonimetry and Alkalimetry. R. J. MANUELE & C. TINNIRELLO. Ind. y Quim. (Buenos Aires), **18**:365, 393 ('57). Detn. of total hardness of water by use of ethylenediaminetetraacetic acid was studied. Error in detg. Ca^{++} as $CaCO_3$ hardness was in range −1.0 to +0.4% in presence of NaCl and −2.0 to +0.4% in presence of Na_2SO_4. Error in detg. Mg^{++} as $CaCO_3$ hardness was 2.8–3.6% in presence of NaCl and 3.2–4.6% in presence of Na_2SO_4. High results with Mg were attributed to procedure which required standardization with Ca^{++}. Method of detg. total hardness by complexonimetry and alkalimetry (PFEIFER–WARTHA method) were compared for 56 treated, boiler, and cooling water samples contg. 2–420 mg. $CaCO_3$/l hardness. Avg. difference was 12 mg/l, and max. was 30 mg/l (3 pairs of values with differences of 115, 126, 130 mg/l being

(*Continued on page 90 P&R*)

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(*Continued from page 88 P&R*)

elimd.). Pairs of values in which differences were greater than 100 mg $CaCl_2$/l occurred in samples contg. 13–16 g/l of dissolved solids among which were polyphosphates. Complexonimetric method is to be preferred for routine detns.—*CA*

Polarographic Determination of Iodine and Bromine at a Solid Anode in Mineral Waters. N. N. ATAMANENKO & E. M. SKOBETS. Ukrain. Khim. Zhur. (USSR), **23**:771 ('57). Mineral water (0.5 liters) is evapd., residue dissolved in 10 ml H_2O, and 5 ml of this soln. mixed with 15 ml-*M* HCl is polarographed by using spiral anode made from 30 mm of 0.4-mm diam. Pt wire and a satd. calomel cathode having 200 sq cm Hg surface. Rotating electrode will det. smaller amts. of I than stationary, but latter gave better results with Br. Calcns. were based on increase in area of peaks (0.48 and 0.96 v for I and Br, resp.) of differential curve caused by small addns. of standard solns.—*CA*

Determination of Oxygen Dissolved in Water in Presence of Nitrites. E. M. YAKIMETS & N. V. SHABANOVA. Trudy Ural. Politekh. Inst., Sbornik (USSR), **57**: 79 ('56). Conditions of prepg. NH_2SO_3H, and its action on NO_2^- were studied. Treatment with NH_2SO_3H does not interfere with detn. of O; NH_2SO_3H should be added before introduction of KI soln. Dissolve 55 g $MnSO_4 \cdot 5H_2O$ and 10 g cryst. NH_2SO_3H in 100 ml H_2O, add 1 ml of this soln. to water sample, after 0.5–1.0 min add 1 ml of soln of 20 g KI and 36 g NaOH in 100 ml H_2O, stir, add 3 ml of 1:1 H_3PO_4 or H_2SO_4, and titrate liberated I with 0.01*N* $Na_2S_2O_3$.—*CA*

Colorimetric Determination of Phosphate in Boiler Water with Molybdenum Blue Color. K. FUJITA. Shigen Kagaku Kenkyusho Iho (Tokyo), **41–2**:81 ('56). From *N* H_2SO_4, 0.75 $(NH_4)_2MoO_4$ and 0.024% $SnCl_2 \cdot 2H_2O$ was formed yellow phosphomolybdate complex with which phosphate in boiler water could be detd. colorimetrically (producing

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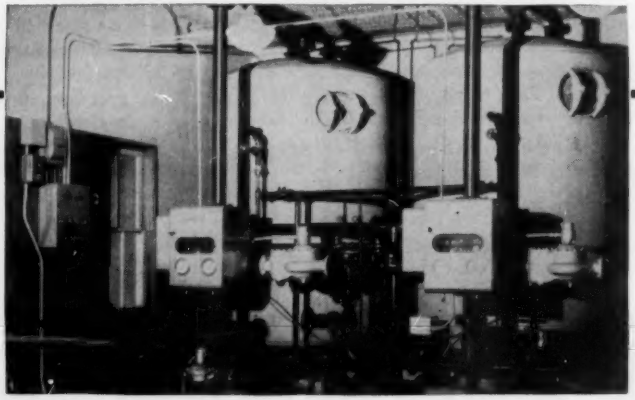

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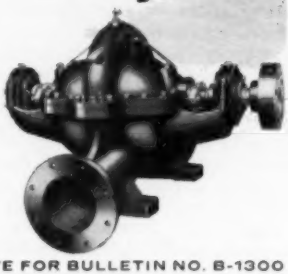

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(*Continued from page 90 P&R*)

blue color by reduction). Tannin and silica in water did not interfere with detn., provided *N* H_2SO_4 was used. Other sol. substances were negligible up to following concns. (ppm): NaCl 10,000 Na_2CO_3 3,000, and Na_2S 60,000. $NaNO_3$ interfered with detn. but could be removed by boiling with 8 g of NH_4Cl/mg $NaNO_3$ for about 20 min. Phosphate in boiler water is gradually exchanged to $CaCO_3$ and Mg $(OH)_2$. Therefore water should be filtered before testing for phosphate.—*CA*

Determination of Iron in Mineral Waters. G. Almassy & M. Z. Kaval. Magyar Kem. Folyoirat (Budapest), **62**:325 ('57). Colorimetric procedure with aniline and bipyridine reagents permits rapid and sensitive (30 γ/l) Fe detn. in natural waters. Fe^{++} ions are oxidized with HNO_3 in 10-ml sample, 0.5 ml aniline and 1 drop bromophenol blue indicator are added and soln. is adjusted to pH 4.7 with 15% NaOAc. Bipyridine (0.2 ml) is added and Fe is colorimetrically detd.—*CA*

Determination of Phosphorus in Natural Waters by Extracting Phosphomolybdic Heteropoly Acid With Butyl Alcohol. V. G. Datsko & A. D. Semenov. Izvest. Akad. Nauk S.S.S.R., Otdel. Khim. Nauk (Moscow), 357 ('58). Detn. of P in natural waters by extraction in form of phosphomolybdic heteropoly acid with BuOH makes it possible to elim. introduction of salt-correction factors. Method, which is applicable in cases where Denise-Atkins method is not, gives more accurate results than D.-A. method.—*CA*

Quality of River Water and Its Pollution. I. The Kako River. S. Okada & K. Uesugi. Himeji Kogyo Diagaku Kenkyu Hokoku (Jap.), **7**:70 ('57). Water samples taken at various places along Kako R. were chemically examd. Samples from upper stream and joining point were remarkably pold. with waste water from factories, especially with sulfides. Foams floating on surface at certain part of river with faint odor of mercaptan contain large amt. of sulfides and had high chem. oxygen demand value. These foams gradually decreased downstream until they almost vanished at river mouth. **II. The Ibo River.** *Ibid.*, 78. Since there are variety of factories in Ibo basin, chem. investigations were made on water qual. with samples taken at river. Amts. of Cl^-, SO_4^{--}, and CaO in samples of lower stream were more than those of upper stream. Higher chem. oxygen demand values were also recognized in samples of lower stream. —*PHEA*

Simple Liquid Scintillation Counter for Chemical Analysis With Radioactive Tracers. W. Seaman. Anal. Chem., **29**: 1570 ('57). Liquid scintillation counter with 1 photomultiplier tube and no refrigeration is simple, inexpensive, and compact. Because it requires higher level of activity than would be available for some applications, it is recommended for anal. uses where necessary levels of activity would not be disadvantageous. Examples of its use are given for counting tritium activity in tritiated triolein and for detg. naphthalene in tar-oil fractions by isotope-diln. method using naphthalene tagged with carbon-14.—*PHEA*

Modified Determination of Radium in Water. F. B. Barker & L. L. Thatcher. Anal. Chem., **29**:1573 ('57). Proposed method embodies barium sulfate carrier pptn., filtration through molecular filter membranes, and collection of activity after prescribed aging period. Method is sufficiently accurate and precise to indicate potability of water and for use in general studies of radium in chem. hydrology. Amts. of radium as low as 0.1 $\mu\mu$c can be detected by using 1-hr counting times. Radium-226 is used as std. and results indicate about 100 to 100% of activity of alpha-emitting radium isotopes as radium-223, radium-224, and radium-226.—*PHEA*

Spectrochemical Determination of Rubidium and Cesium in the Mineral Waters of Niska Banja, Yugoslavia. S. Ristic; S. Arsenijevic; & V. Milutinovic. Glasnik Khem. Drushtva, Beograd. (Yugo.), **21**:283 ('56). Prelim. investigation of physiocochem. properties of mineral waters of Niska Banja (Serbia), including semiquant. spectrochem. detn. of some elements (Li, Br, Cs), revealed presence of all alkali metals (except Fr). Presence of Li, Rb, and Cs might be of special geochem. importance. Absence of any quant. of U and Th (over estd. sensitivity limit of about 10^{-4} g/l) makes new and thorough study, especially of radioactivity of this water, very desirable. Spectrochem. anal. revealed no traces of U

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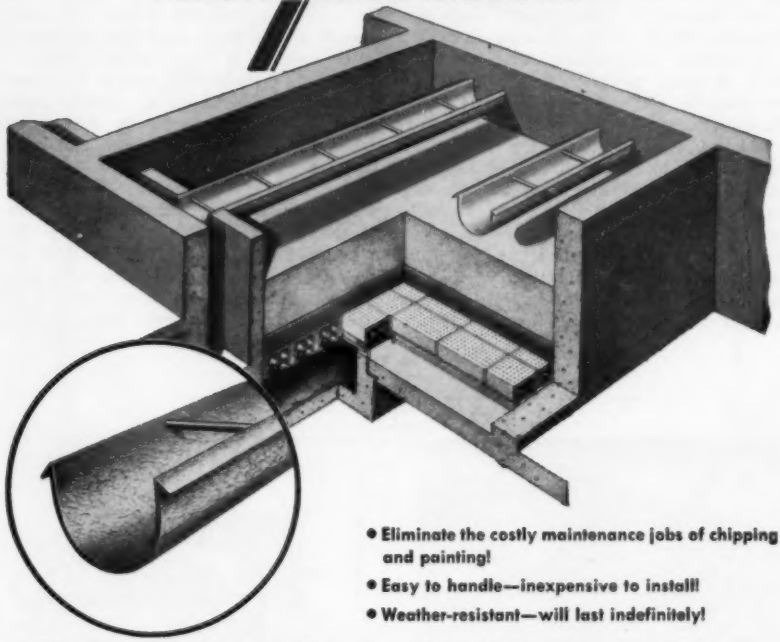

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(*Continued from page 92 P&R*)

and Th in dry residue of water. Fluorometric test (made after special chromatographic concn.) revealed 4.10^{-4} g/l U, which corresponds to avg. U cont. of rocks exposed to subaerial weathering.—*CA*

Methods for the Calculation of the Salt Contents and the Concentration of the Major Ions in the Water of Open Firths. A. M. ALMAZOV. Gidrokhim. Materialy (Moscow), **27**:96 ('57). Mixing formulas are presented which show how to calc. compn. of water of open firths from water contributed by sea and by river(s) (1 formula for 1, other for 2 rivers). 2 formulas are derived for calcg. ion concns.; 1 is valid for high tot. salt cont., other for low. There is finally given eq, which permits calcn. of vols. of sea and river H_2O which contributed to form fifth. These formulas were applied to Dnieper, Dniester, and Bug river firths; it was found that calcd. and experimentally found values agreed within 2%.—*CA*

A Graphical-Analytical Method for the Determination of the Precipitation of Salts From Subsurface Waters in the Process of the Increase of Their General Mineralization. I. Y. DAVYDOV. Izvest. Akad. Nauk Turkmen. S.S.R. (USSR), **4**:24 ('57). Such method can be devised, as formulation of chem. compn. of subsurface water and salt enrichment of soils go hand in hand. In order to establish graphs all anal. in waters and in soils must first be run. Sol. salts contain ions as HCO_3^-, SO_4^{--}, Cl^-, Ca^{++}, Mg^{++}, and Na^+, which will lead to formation of insol. salts. Graphs make it possible to read amts. of pptd. $CaSO_4$, $CaCO_3$, etc., and also of amts. and kinds of sol. salts which remain in soln.—*CA*

Colorimetric Determination of Silica in Water. J. JUSTATOWA. Zeszyty Nauk. Politch. Lodz. Chem. (Pol.), **5**:93 ('57). Solns. of K_2CrO_4 and of picric acid, used as stds. in colorimetric detn. of SiO_2 by NH_4-MoO_4, were investigated. Simple colorime-

(*Continued on page 96 P&R*)

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(*Continued from page 94 P&R*)

ter with Hehnel cylinders was used. In SiO_2 concn. range of 1–30 mg/l solns. of 5.34 g K_2CrO_4/l with 5 g $K_2B_4O_7$/l and 0.682 g picric acid/l can be used. Larger concns. of picric acid gave too low results. —*CA*

Estimation of Silica in Water. L. Sassi. Arch. Inst. Pasteur Tunis (Tunisia), **32**: 283 ('55). Yellow ammonium silicomolybdate is reduced with hydroxylamine chloride in presence of diammonium citrate to give blue color which can be measured photometrically.—*CA*

Determination of Sodium, Potassium, and Calcium by Flame Photometry in Water From the Departments of Lima and Ica. I. P. Borias. Anales Fac. Fam. y Bioquim., Univ. Nacl. Mayor San Marcos (Lima), **6**: 533 ('55). Water samples (60) from rivers, wells, and hot and medicinal springs were analyzed with Beckman flame photometer. Conts. in potable water, of Na were 18.9–2,180, of K 1.0–8.4, and of Ca 47.5–175; in Chilca spring water, Na 11,000–12,020, K 625–890, and Ca 875–1,000 mg/l. Std. of 70 mg Na, 5 mg K, and 500 mg Ca/l was used for comparison.—*CA*

Quantitative Analysis of Sulfate Ions in Natural Water by Titration With Ethylenediaminetetraacetate. K. Fujita. Shigen Kagaku Kenkyusho Iho (Tokyo), **45**: 50 ('57). Sample of water (filtered if foreign particles are afloat) was passed through cation-exchange resin, and, after dropping 3 drops of 1:1 HCl and adding 10% 0.01*N* $BaCl_2$, heated to boil. After cooling to room temp. 0.01*N* ethylenediaminetetraacetate was added with buffer soln. and indicator (Eriochrome Black T) and then back-titrated with 0.01*N* $MgCl_2$ for SO_4^{--}, liquid turning from blue to grape-red at end point. Method is accurate within 0.2–0.3 mg/l.—*CA*

A Modified Method for the Determination of Suspended Matter in Water and the Loss on Ignition. M. Enger. Gas-u. Wasserfach. (W. Ger.), **99**:488 ('58). Results for suspended matter in water obtained with fritted-glass filter funnels on asbestos mats in Gooch filters vary considerably. Pore size of glass filters is variable, and these filters are readily clogged, while wt. of asbestos filter changes with water absorption, on ignition, and on later water absorption. Glass fiber filter paper prepd. by Schleicher and Schull for chromatographic work gave much better results. Change in wt. due to water absorption was slight and loss on ignition at 650°F was negligible after single ignition. In test, 500 cc water is passed through filter, this is then dried at 105°F, weighed, and loss on ignition obtained by heating to 650°F. Filtrate from glass fiber filter paper is much clearer and has lower Fe cont. and $KMnO_4$ consumption than does filtrate from glass filter or asbestos filter. Comparative results are given. Results from different labs. should be much more comparable with glass fiber filter paper.—*CA*

Determination of Uranium in Natural Waters. L. L. Thatcher & F. B. Barker. Anal. Chem., **29**:1575 ('57). Fluorophotometric detn. of uranium was studied to develop procedure applicable to routine anal. of water. 3 g of high-carbonate flux are used in diln. procedure with spiking. Because of comparatively high reflectivity of this large disk and low uranium concn. correction for nonquenched light is required. Formula is developed to compensate for effect, electrical fusion device is described, and problem of fixing uranium in waters is discussed.—*PHEA*

The Colorimetric Determination of Zinc in Water Using Brilliant Green and Thiocyanate. G. U. Houghton. Proc. Soc. Water Treatment Examn., **6**:60 ('57). Sensitive method is proposed for detn. of zinc in drinking waters depending on its reaction with Brilliant Green in acid soln. contg. thiocyanate. In series of 12 check anals. on accuracy ±8% or better was demonstrated. Aluminum and lead (10 ppm) do not interfere and interference by copper and iron is not serious for conts. of these metals up to 3 ppm.—*PHEA*

Content of Lead and Mercury in the Water of the Saale River. F. Heide; H. Lerz; & G. Bohm. Naturwissenschaften (Berlin), **44**:441 ('57). Sampling of water of Saale R. at Goschwitz over 1-yr period shows avg. tot. Hg cont. of 0.088 γ/l and Pb cont. of 19.4 γ/l. Totals comprise: dissolved, Hg 0.067, Pb 8.8; suspended, Hg 0.021, Pb 10.6 γ/l. Regional probes along

(*Continued on page 98 P&R*)

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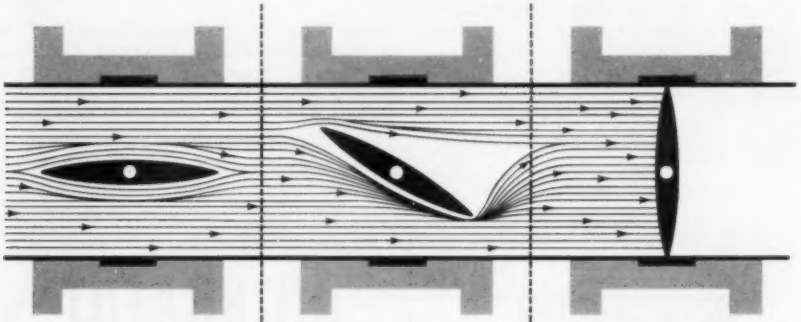

FREE FLOW WHEN OPEN
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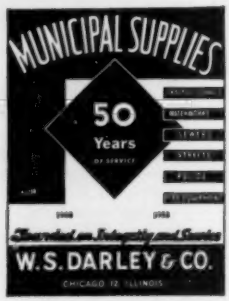
(*Continued from page 96 P&R*)

Saale indicate slight increase in Pb and Hg concn. toward mouth of river, except for variations caused by industries. Hg:Pb ratio of 1:220 is of order of magnitude of that found in earth's crust.—*CA*

Analysis of Water of Darjeeling Town in the Monsoon Season. S. R. SARKAR. J. Proc. Inst. Chemists (India), **29**:209 ('57). Chem. anal. of water (predominantly spring water) before onset of monsoon season indicated relatively high cont. of impurities: tot. solids 9,100–10,200; Cl 800; permanent hardness 1,100–1,900; temporary hardness 300; free and saline NH_3 22; albuminoid NH_3 22–25; O 429–440, and nitrate *N* 90 ppm. During monsoon season, all constituents decreased markedly: tot. solids 2,400; Cl 400–500; free and saline NH_3 8–12; albuminoid NH_3 18–19; permanent hardness 1,050–1,200; temporary hardness 30–35; O 150–250; and nitrate *N* 50–53 ppm. During postmonsoon period of declining rainfall, all figs. were low (except NH_3); tot. solids 1,000–1,420; Cl 300–400; permanent hardness 1,000–3,000; temporary hardness 200–800; free and saline NH_3 8–14; albuminoid NH_3 15–22; O 110–143; and nitrate *N* 55–57 ppm. Constituents probably represent vegetable impurities. Coliform-bacteria count of spring water was 180/100 cc in premonsoon period and 160/100 cc during and after monsoon period. Study was made of effectiveness of water treatment consisting first of bleaching powder (6 lb/day in dry season, 12 lb/day in wet season), then alum (56 lb/day), followed by filtration (in pressure filter with 45 ft head of water), and finally, chlorination before storage in main tanks in town. Total treatment was found to be fairly effective with no coliform-organism count after chlorination.—*PHEA*

Analysis of Water From Three Wells at Anconetta (Vicenza), Intended as Supply to Padua's Aqueduct. U. CARRETTA & J. BASTIANUTTI. Atti Ist. Veneto Sci., Lettere ed Arti, Classe Sci. Mat. e Nat. (It.), **114**:17 ('55–'56). Water from depths of

(*Continued on page 100 P&R*)



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(*Continued from page 98 P&R*)

130–150 m was potable pH 7.75–7.88, radioactivity negligibly small, hardness 3.1–4.6 me/l (Ca^{++}, Mg^{++}, HCO_3^-, SO_4^{--}, smaller amts. of Na, K, Al, Cl, NO_3, and PO_4). Spectrometry showed traces of Li and more than 20 γ/l Fe. Dissolved gases were: CO_2 4.2–7.8, O 6.9–7.5, N and inert gases 21.3–23.5 ml/l. None of samples contained aggressive CO_2; SiO_2 cont. was 10.6–13.2 mg/l.—*CA*

The Sulfur Mineral Water From "Bagni" Spring in Ferentino (Frosinone). I. NAPOLI. Boll. Lab. Chim. Provinciali (Bologna), **8**:206 ('57). On basis of anal. data this water appears in MAROTTA and SICA classification as being "sulfurous, calcium bicarbonate bath water."—*CA*

Analysis of Water From Two Sources Near Navene, Malcesine Township, Verona. U. CARRETTA. Atti Ist. Veneto Sci., Lettere ed Arti, Classe Sci. Mat. e Nat. (It.), **114**:7 ('55–'56). 2 springs (Navene and Pozzini) were sampled; their hardness, low to medium, was mainly Ca and Mg as sulfates and bicarbonates. Na, K, and silicates were present in small amts., with traces of Fe, Al, Li, and chlorides. Dissolved gases were approx. 16.5 ml N and inert gases, 7 ml O, and 3–4 ml CO_2/l. Radioactivity was 0.48 and 0.10 μc/l, resp.—*CA*

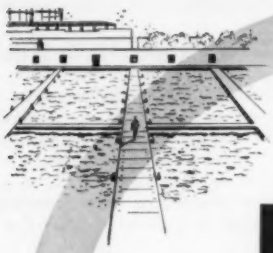
The Springs and Underground Waters in Volcano Asama and Its Vicinity. I. Chemical Composition of the Springs and Underground Waters in the Zyabori River Valley and Its Neighborhood. J. OSSAKA ET AL. Bull. Earthquake Research Inst., Tokyo Univ. (Jap.), **35**:395 ('57). Anals. of 31 samples are given. They are high in Ca and CO_2, low in Cl, and low in SO_4 (except 2), and high in H_2SiO_3 (as high as 116.7 mg/l).—*CA*

Chemical Studies on the Hot Springs of Beppu. VI. Distribution of Titanium. A. KOGA. Nippon Kagaku Zasshi (Tokyo), **78**:1713 ('57). Ti was detd. photometrically with H_2O_2 after copptg. with Fe. Avg. of 37 springs is 87 γ Ti/l, with range 14–298 γ/l. Concn. of Ti is not related to that of Fe. Acid springs contain relatively much Ti. **VII. Distribution of Silver.** *Ibid.*, 1717. Ag was detd. photometrically with *p*-dimethylaminobenzylidenerhodanine after copptg. with Te. Avg. of 31 springs is 11 γ Ag/l, with range 0.0–57.0 γ/l. Springs of Myoban and Kannawa are extremely high in Ag, avg. being 39.0 and 22.8 γ/l, resp. Relatively much Ag is found in acid and bicarbonate springs. Concn. of Ag is related to that of Zn. **VIII. Distribution of Boric Acid.** *Ibid.*, 1721. B in 57 springs was detd. with curcumin; 54% of springs contain 10–50 mg H_3BO_3/l, 31% contain <10 mg/l, 13% contain 50–100 mg/l, and 2% contain >100 mg/l. In springs of Myoban and Kannawa concn. of H_3BO_3 is proportional to that of Cl, and in springs of Kamegawa it is proportional to that of H_2CO_3.—*CA*

Estimation of the γ Amount of Thorium in the Lake Biwa Water. M. ISHIBASHI & S. HIGASHI. Bull. Inst. Chem. Research, Kyoto Univ. (Jap.), **35**:1 ('57). L. Biwa water contained 5.83×10^{-5} γ Th/l, as detd. by analyzing floc obtained at Water-Supply Dept., Kyoto City. To det. Th cont., floc was sampled, accumulation factor of Th was detd. by using Ti as internal indicator, Th extracted from floc by cyclohexanone was detd. colorimetrically, and amt. calcd.—*CA*

Chemical Investigations of Hot Springs in Japan. Spectrographic Studies on Minor Metallic Constituents in Hot Spring Waters of Hokkaido. M. NISHIMURA. Nippon Kagaku Zasshi (Tokyo), **79**:172, 183 ('58). Residues on evapn. from waters of 107 hot springs from 52 localities in Hokkaido were examd. by d-c arc-spectrographic anal. Al, B, Ca, Fe, Mg, Mn, Si, and Cu were detected in all samples. Following elements were also detected: Li (in 86% of all springs), Ti (76%), Ba (72%), V (69%), Pb (62%), Ag (41%), Mo (33%), Ge (21%), Cr (19%), P (14%), Ni (14%), Ga (12%), As (7%), W (5%), Sb (5%), and Zr (4%). Approx. limits of detection of these elements are given. Approx. conts. of Ge, Pb, and Sb in residues from hot spring waters were detd. Relatively high Ge is found in strongly alk. and simple springs contg. H_2S. Ga is found not only in this type of spring but in strongly acid waters. Avg. Pb concn. is approx. 10^{-3}% with respect to residue on evapn. Spring that gives positive lines of Sb always shows presence of As. Cr and Ni are detected in springs located in central Hokkaido.—*CA*

(*Continued on page 102 P&R*)



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(*Continued from page 100 P&R*)

Geochemical Studies on Mineral Springs in the Tohoku Districts. XV. The Narugo Spring Group. K. Arii & S. Nagasawa. Sci. Repts. Tohoku Univ., First Ser. (Jap.), **39**:246 ('56). Mineral components of spring waters were detd. in '51 and compared with '48 detns. Typical spring yields water, temp. 81°F, contg. (mg/l) chloride 660, sulfate 527, thiosulfate 24, borate 95, H_2S 12, bicarbonate 199, carbonate 18, and permanganate reducibles 82. Chloride, sulfate, and thiosulfate concns. are generally lower than in '48, perhaps owing to low rainfall prior to '51 sampling.—*CA*

Geochemical Studies on the Hot Springs at Yakumo Mine, Hokkaido. I. Kayama & T. Iriye. Nippon Kagaku Zasshi (Tokyo), **78**:989 ('57). Springs found at rhodochrosite-producing Yakumo mine are classified in 2 groups of high and low temps. Avg. chem. compns. of waters of high- and low-temp. groups are, resp.: temp. 59.9° and 39.4°F; Cl^- 72.98 and 37.65; SO_4^{--} 16.38 and 16.27; Ca^{++} 26.07 and 31.17; Mg^{++} 5.67 and 5.89 me/l, residue on evapn. 6.58 and 4.72 g/l.—*CA*

Geochemical Study of Acid Waters in Japan. I. Natural Waters in the Eastern Part of Yatsugatake Volcanoes. T. Hanya & Y. Sugimura. Nippon Kagaku Zasshi (Tokyo), **78**:1307 ('57). Chem. compns. are given of many branches, including Yukawa R., of Chikuma R. Waters of Yukawa R. are different from others in being acid, with low bromocresol green alky., high sulfate-ion concn. (0.6–1.2 me/l), and max. chloride-ion concn. (0.20 me/l). SiO_2 concn. (about 20 mg/l) and elec. cond. ($0.2–0.5 \times 10^{-4}$ ohm^{-1} cm^{-1}) are much same for all river waters. **II. The Upper Course of the Yukawa River.** *Ibid.*, 1312. Waters of upper Yukawa R. were sampled at 27 points for chem. anals. Waters, having pH values of about 3 and 2.3, correspond to bromocresol green acidity of 2–3 and 4–10 me/l, resp. As acidity increases sulfate-ion concn. increases. Ca concn. is higher than Mg concn. Silicic acid concn. is 0.3–1.46 $\times 10^{-3}M$.—*CA*

Degree of Mineralization of Underground Waters of the Territory Surrounded by Braila-Danube-Siret. B. Iancovici. Acad. Rep. Populare Romine, Bul. Stiint., Sect. Biol. Stinte Agr. (Rum.), **9**:1:29 ('57). Cont. of salts of 3 rivers, Braila, Danube, and Siret, and their influence on compn. of soil were studied. These waters were divided according to their cont. in minerals: waters contg. <2 g/l Ca bicarbonates, waters with 9–12 g/l of NaCl, and waters with 2–5 g/l of other various salts. Cont. of salts in soil was low where little or no inundation occurred, but higher in flood plains.—*CA*

Composition of the Water of the Main Azov Channel and the Problem of Its Source. N. G. Fesenko & A. A. Zenin. Gidrokhim. Materialy (Moscow), **25**:176 ('55). It was found that anals. for main ion in H_2O hardly change over full length of main Azov R. channel. Irrig. properties of these waters are utilized to limits of safety. Anals. show that water of this channel comes not only from Veselovsk Res. (close by), but also from rather remote Egorlyk Res. Constr. of Nevinnomyssk Canal (close by) has hardly influenced water anals. of this main Azov channel.—*CA*

Determination of Organic Materials in the Dnieper Water by Their Oxidation. T. N. Gorizontova & N. E. Sarancha. Gidrokhim. Materialy (Moscow), **27**:49 ('57). Org. matter in river varies. It reached max. in Jun. '55. There was also some inorg. matter present which used up O prior to '54–'55, which is accounted for by industrial plant sewage, before any treatment was prescribed by law. Among various methods used bichromate oxidation with phenylanthranilic acid as indicator is recommended because color change from violet to green is clearly noticeable at end point of titration. Also, in this titration no H_3PO_4 needs to be added, which is not true if diphenylamine is used as indicator.—*CA*

The Chemical Composition of the Waters in the Reservoirs of the Forest-Steppe Zone of the "Leftside Wells," Eastern Ukraine, Exemplified by the Lozovenki Reservoir. A. L. Bugaiov. Dopovidi Akad. Nauk Ukr. R.S.R. (USSR), **1**:55 ('58). Chem. compn. of this reservoir and of all rivers, brooks, and wells which feed into it was investigated (271 anals.). Reservoir water composed of rain water, water from rivers, etc., and underground water. Mineral compn. with respect to Ca^{++} and CO_3^{--} changed owing to hydrobiology and other processes.—*CA*

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FIG. 571X
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- Parallel Seats
- Mechanical Joint Ends

FIG. 001
- Inside Screw
- Non-Rising Stem
- Parallel Seats
- Flanged Ends

FIG. 366
- Outside-Screw-and-Yoke
- Rising Stem
- Parallel Seats
- Flanged Ends

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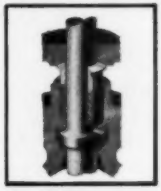

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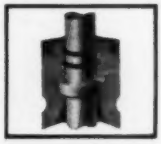

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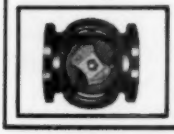

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Correspondence

Well's Well

To the Editor:

I read with interest the P&Rticles in the February (p. 48) and March (p. 52) issues on Chalmer Lovdahl's "hot" well near Monmouth, Ill. As a member of the State Geological Survey, I worked on Mr. Lovdahl's problem in late November 1958.

The well is an 18-in. augered and tiled type, about 17 ft deep, completed in the glacial drift. It is pumped by suction with a small unit located in a utility shed right beside the well. About 200 ft away is a drilled well cased into and completed in Mississippian limestone. Water temperature in this well remained normal throughout the episode.

Mr. Lovdahl first noticed that the water in the dug well was starting to get warm last August. When a chemist from the State Water Survey visited the well in October, he found that the temperature of the water was over 90°F. He made no other study.

William H. Walker, associate engineer with the State Water Survey, and I made a study at the well on Nov. 26, 1958. We ran a thermistor (temperature) survey and found that the temperature ranged from about 88° at the top (nonpumping level 6½ ft) to about 62° at the bottom. We found that after the well was pumped dry, the water entering it between the tiles at a depth of about 12 ft was about 90°. Water entering the well at a lower level was cooler.

(*Continued on page 106 P&R*)

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(Continued from page 104 P&R)

From our inspection of the premises we had decided that the most logical explanation for the hot water was that there was a leak in the pipe running into the house from a hot-water heater in the utility shed. This suspicion was confirmed when we found that the hot water was coming from above rather than from below and that the water temperatures in nearby hand-augered holes increased toward the well (and the adjacent hot-water pipe).

Mr. Lovdahl was reluctant to admit the possibility of a leak because he continued to get hot water in the house under good pressure, and because, prior to our visit, he had had the water heater turned off for 2 weeks.

On Nov. 28 I returned to the well and, with Mr. Lovdahl, dug down to the hot-water pipe at a point where Mr. Walker and I suspected the leak to be. We found a leak in the copper tubing which ran within a few inches of the well tiles. The leak was small enough to permit a residual flow of water into the house, and the ground was a good enough insulator to hold the heat of the pocket of leakage water for several weeks when the heater was turned off.

Mr. Lovdahl was a good sport about the whole thing and was in the process of getting the leak repaired when I left.

ROBERT E. BERGSTROM

Assoc. Geologist, State Geological Survey Div.

Urbana, Ill.

Mar. 18, 1959

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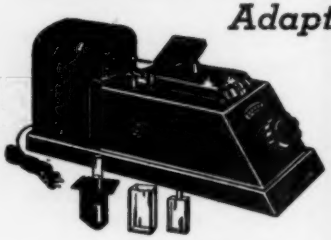
ELECTRIC PHOTOMETER

Adaptable for Use in Water Analysis



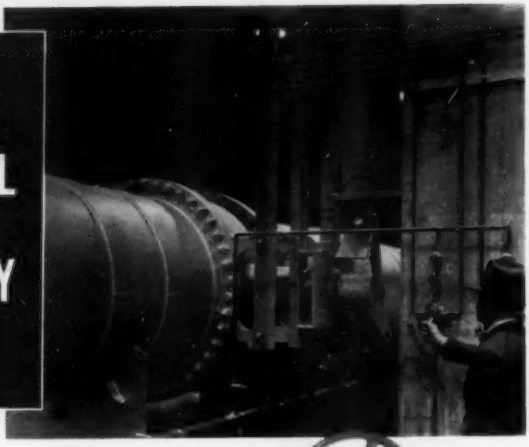
Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.

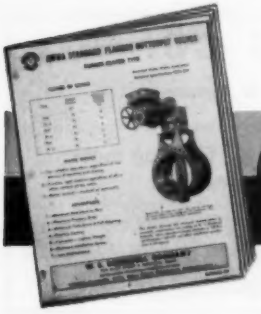
179 EAST 87th STREET · NEW YORK, N. Y.

at the Massena, N. Y., intake of the St. Lawrence Project

they've installed ROCKWELL AWWA BUTTERFLY VALVES



Yes, five 48" diameter Rockwell valves passing some 40 million gallons of water daily. Two of these valves at the canal intake are equipped with extended stems and worm gear handwheel units for remote control; the three valves in the power plant are equipped with hydraulic cylinders and 4-way control valves. All have Rockwell's exclusive Wedge-Lock rubber seat insert for drip-tight shutoff.



There are many such successful Rockwell valve installations for water applications. Bulletin 581 tells why.

ROCKWELL SINCE 1888 BUILT

BUTTERFLY VALVES

W. S. ROCKWELL COMPANY

2609 Eliot Street, Fairfield, Conn.

(*Continued from page 52 P&R*)

Philip F. Morgan, professor of sanitary engineering at Iowa State University, has been named mayor of Iowa City. He will serve a 1-year term in the post.

David B. Lee, director of sanitary engineering, Florida Board of Health, has been accorded the honor of having the sewage treatment plant at Eau Gallie, Fla., named for him.

T&O complaints? Now you have the perfect answer! Two Swedish scientists have determined incontestably that humans cannot taste water—that only monkeys, pigs, dogs, and cats can taste it. Well! Name your customer!

Speaking of animals, reports of beaver, deer, and muskrat from New Jersey and North Carolina watersheds have us ready to turn in our SPCA card for a hunting license. True the beaver tale from the Wanaque Reservoir of the North Jersey District Water Supply Commission is billed as a happy one of a band of dam rodents keeping silt penned up in the marshes and killing off alder and other inferior species of trees, but if we remember correctly their shallow ponds next season will be algae incubators to keep the reservoir well seeded. The dear deer of the East Orange, N.J., water reserve are also getting out of hand, a herd of 1,000 feasting on citizens' shrubs and tulips and causing a total of 92 auto accidents in a year. A new attempt to reduce the herd by trapping during the winter season promises some venison but no great success. And at Monroe, N.C., the city's new water supply reservoir has been threatened by muskrat burrows all along the top of the dam. As the price of muskrat pelts has fallen, the peltiferous population has increased until that in the Monroe area has amounted to an infestation. Noting that reservoir burrows were regularly from 6 in. to 1 ft below water surface, Monroe authorities built a $1,100 6-ft concrete apron around the top of the dam, thwarting their ravages. But did someone say our four-footed fiends?

Odie E. Walker, vice-president and works manager, Mueller Co., Decatur, Ill., has been named executive vice-president and general manager of the firm's Canadian subsidiary, Mueller, Ltd. Walker has been a company vice-president since 1950.

M. J. Shelton, former deputy director of the California Dept. of Water Resources, will head the new San Diego office of the consulting firm of Koebig & Koebig.

(*Continued on page 110 P&R*)

MONTEREY SAND CO.

Crystal Amber Filter Sand & Gravel

"The Standard of the Industry"

In conformity with A.W.W.A. specifications for filtering material or made to your own specification.

Shipped Bulk or in 100 lb. bags.

Filtration specialists for over 15 years

P. O. Box 928, Monterey, Calif. — Inquiries Invited

WARNING!

SUMMER'S ON THE WAY

STANDARDIZE ON

CALMET

WATER METERS

Assure your community of Sustained Accuracy. With CALMETS in the lines, you know that you'll be receiving the maximum revenue for your Water Department . . . and with a very minimum of maintenance . . . due to CALMET'S long, rugged life.

WRITE or WIRE TODAY

WORTHINGTON CORPORATION

CALMET METER DIVISION

2301 SO. MAIN • FORT WORTH, TEXAS

(Continued from page 108 P&R)

Legal notes: *Suburban supply.* The Wisconsin Public Service Commission has granted permission to two communities now served by Milwaukee to build their own supply facility. The case had been contested by Milwaukee on the ground that it had invested a considerable sum in facilities to furnish water to these towns. The city argued further that it was unjust for the commission to order it to serve a suburb in one instance (Wauwatosa; see July 1958 P&R, p. 48) and then, as in the present instance, permit suburban communities to discontinue taking water from the city. The commission, however, countered that it was "unable to find that remaining customers of the Milwaukee water utility will in any way be injured by the loss of the wholesale business involved herein."

Pollution control. New York State's power to compel localities to build major pollution control facilities regardless of cost has been upheld by the highest judicial body in the state, the Court of Appeals. It ruled that the State Water Pollution Control Board has the authority to set standards for the degree of pollution permissible and to require cities to adhere to these standards even in the face of a claim by a municipality that it cannot afford to build the necessary sewage treatment facilities.

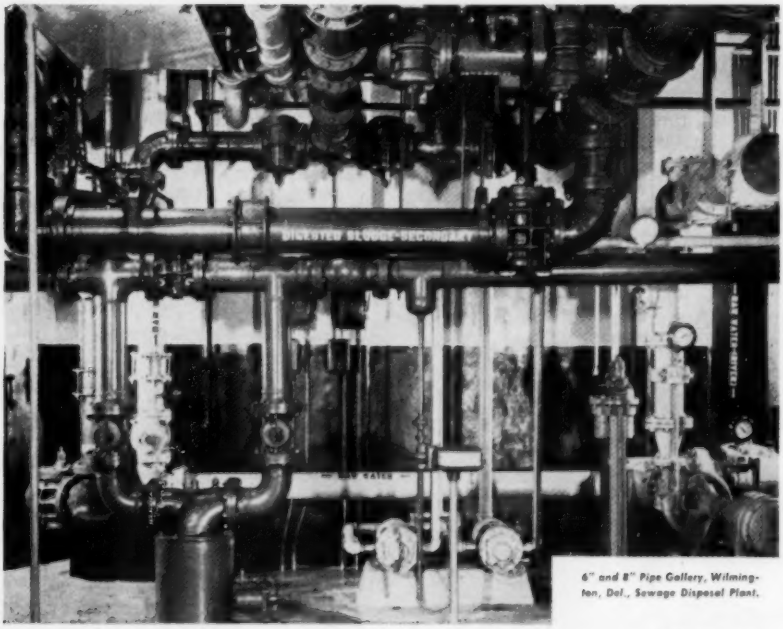
Water rights. The state of Michigan, supported by New York, Wisconsin, Ohio, Pennsylvania, and Minnesota, has again gone to the US Supreme Court to compel Chicago to treat and return to Lake Michigan the 1,800 cfs the city is now diverting and ultimately discharging into the Mississippi via a drainage canal. Michigan contends that shipping, property values, and recreational interests are being adversely affected. An earlier appeal to the Supreme Court was rejected for lack of specific charges. (According to Ivan W. Brunk, supervising meteorologist at the Chicago weather bureau, however, the diversion is only 1,500 cfs and is more than compensated for by the 5,000 cfs now flowing into Lake Superior.)

Oliver M. Bakke Sr., vice-president of Houston Labs., consulting chemists of Houston, Tex., died Feb. 2, 1959. Born in St. James, Minn., he was a graduate of the University of Minnesota. Before joining Houston Labs. 29 years ago, he worked as a chemist for the St. Louis & Southwestern Railroad, was in charge of the Dallas, Tex., water treatment plant in 1923–27, and served as chief chemist for Imperial Sugar Co., Sugar Land, Tex. An AWWA member since 1939, he also belonged to ACS, National Assn. of Corrosion Engineers, and Texas Society of Professional Engineers.

Hardy Cross, former head of the Dept. of Civil Engineering at Yale and originator of the widely used method of distribution system flow analysis that bears his name, died Feb. 11, 1959, in Virginia Beach, Va. He was 74. A holder of degrees from Hampden-Sydney College, Massachusetts Institute of Technology, and Harvard, he taught at Hampden-Sydney, Norfolk Academy, Brown University, and the University of Illinois before coming to Yale. From 1906 to 1910 he served as an engineer in the bridge department of the Missouri Pacific Railway. He had been in retirement since 1951.

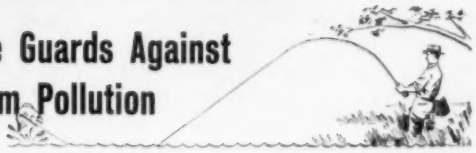
Among the honors Dr. Cross had received were the Norman Medal of

(Continued on page 112 P&R)



6" and 8" Pipe Gallery, Wilmington, Del., Sewage Disposal Plant.

Cast Iron Pipe Guards Against Stream Pollution



Every 12 hours a contract is let for a new sewage treatment works to clean up America's waterways and protect the public health.

Into these plants go thousands of tons of enduring cast iron pipe and fittings. Engineers designing these plants know that no other pipe material compares with cast iron in withstanding the corrosive effects of strong sewage, acids and treatment chemicals. And none has equal strength or a matching time-proved record of long life and low cost service.

Engineers also specify large cast iron pipe for sewer force mains to operate under pressure where strength, longevity and a minimum of jointings are a vital factor. So cast iron pipe not only serves to bring water to our cities and towns but takes it away for cleansing treatment and returns it pure for use again.

Our Company does not manufacture cast iron pipe but supplies many of the nation's leading foundries with quality pig iron from which quality pipe is made.

WOODWARD IRON COMPANY

Since 1882

WOODWARD, ALABAMA

(Continued from page 110 P&R)

ASCE, the Wason Medal of the American Concrete Institute, and the Lamme Medal of the American Society of Engineering Education.

Paul C. Laux, superintendent of the Columbus, Ohio, Div. of Water, died Feb. 28, 1959. Prior to coming to Columbus, he had operated treatment plants at Anderson, Ind., and in West Virginia. An AWWA member or representative since 1935, he served as coordinator for the preparation of the AWWA lime standards. His achievement in developing a flash test for free residual chlorination was recognized by the Indiana Section in nominating him for the Fuller Award, which he received in 1941.

Willem Rudolfs, authority on water and sewage problems and former chairman of the Dept. of Sanitation, Rutgers University, New Brunswick, N.J., died Feb. 20, 1959, at his home in Joppe, the Netherlands. He was 73 years old. The Dutch-born scientist, who retired in 1952, headed the university's experiment station for 30 years. He also served as consultant to a large number of international, public, and industrial organizations. An AWWA member since 1935, Dr. Rudolfs was for many years a prolific contributor to the JOURNAL "Condensation" section.

Arthur D. Weston, consulting sanitary engineer, Edgartown, Mass., died Dec. 19, 1958, at the age of 74. Born in Boston in 1884, he was educated at Dartmouth College. He joined the Massachusetts Dept. of Public Health in 1905 and, except for the years 1908–12 and a period of military service during World War I, remained there until his retirement at the end of 1949. He became chief sanitary engineer and director of the department's Div. of Sanitary Engineering in 1930. In 1948 he was designated deputy commissioner.

A Life Member of AWWA (joined in 1927), Mr. Weston received the Fuller Award in 1957 on nomination by the New England Section. He was past president of numerous professional organizations, including Boston Society of Civil Engineers, Northeastern Section of ASCE, NEWWA, New England Sewage & Industrial Wastes Assn., and Engineering Societies of New England. He also served as chairman of the Conference of State Sanitary Engineers.

Employment Information

Classified ads will be accepted only for "Positions Available" or "Position Wanted." Rate: $1.50 per line (minimum $5.00), payable before publication. Deadline for ad copy: first of month prior to month of publication desired. To place ad, obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 2 Park Ave., New York 16, N.Y.

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WATER AND SEWERS

Graduate sanitary engineer wanted with minimum 3 years' experience in an administrative capacity of water filtration plant and water system operations and/or sewage disposal systems. Salary range $6408 to $7356. Eligibility for Professional Engineers license preferred but not required. Send resume and application to City Administrator, City Hall, Batavia, New York.

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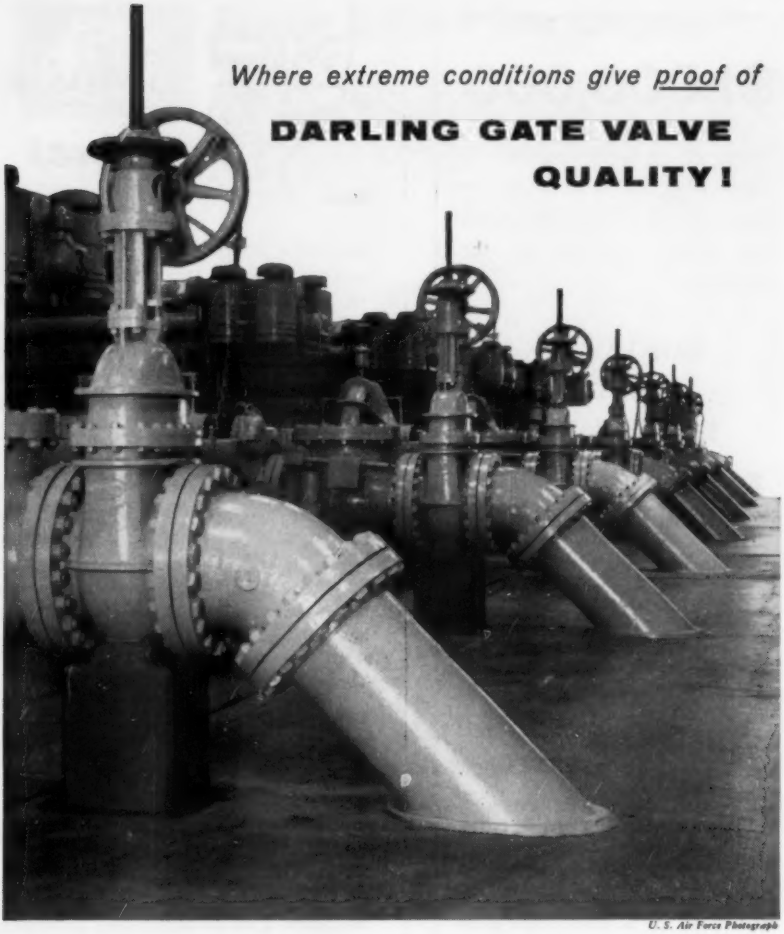
CIVIL SERVICE COMMISSION
Announces Test for
HYDRAULIC ENGINEER
MUNICIPAL WATER SYSTEM

Liberal Fringe Benefits, Job Stability. Requires 5 years' experience in engineering, and college or university graduate in Engineering. APPLY: PERSONNEL OFFICE, CITY HALL, TUCSON, ARIZONA, before closing date: April 30, 1959.

Where extreme conditions give proof of

DARLING GATE VALVE QUALITY!



U. S. Air Force Photograph

From zero to 30,000 gpm demand...suddenly!

Fast pressure changes and heavy line surges are the rule in this system supplying water to the rocket launching pads at a large Air Force test center. The Darling valves installed here must take this severe service in stride . . . and still continue indefinitely to provide smooth, positive response!

There are a number of Darling valve features that assure such performance—features that can help avoid trouble and maintenance in your service, too! For example there's the automatic seating compensation, uniform wear distribution and drop-tight closure assured by Darling's unique gate principle with its fully revolving double discs and parallel seats. You are certainly welcome to complete data on Darling gate valve features, sizes and types. Get *all* the facts! Send for Bulletin 5710.

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VALVES

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worth of research available in convenient, usable form at less than the cost of printing, which was largely absorbed by the JOURNAL.

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Presents the facts of life (and death) of the facilities of water supplies serving almost 10 per cent of all U. S. consumers plus 400,000 Canadians.

576 pages

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Special price to members who send cash with order $2.40

American Water Works Association
2 Park Avenue New York 16, N. Y.

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Butterfly valves are described, with cutaway drawings and dimensional data, in a new two-color, two-page bulletin. The information on these lightweight and compact valves may be obtained by writing for Bulletin 650.20-1 to B-I-F Industries, Inc., 345 Harris Ave., Providence 1, R.I.

Automatic analyzers for water treatment are included in the subject matter of an 84-page catalog that contains sections on simplified procedures for analysis, portable testers, laboratory apparatus, and chemicals and solutions for water testing. Catalog No. 6 is available on request from Hach Chemical Co., Ames, Iowa.

Rustproof paints and coatings are listed and described in a full-color, 36-page booklet. Complete with color charts and instructions for paint application, the booklet (Form 257) may be obtained from the Rust-Oleum Corp., Evanston, Ill.

Manhole guards and traffic barricades are among the equipment illustrated in a 12-page, two-color catalog titled "Sentry All-Steel Barricades and Traffic Control Products." Copies may be obtained from Traffic Equipment Co., 2064 S. Bannock St., Denver 23, Colo.

Deep well turbine pumps, available in water-lubricated and oil-lubricated models, are described in a new three-color bulletin that unfolds into a chart with cutaway drawings. The information on the Type G pump is available by writing Byron Jackson Pumps, Inc., Box 70, Lawrenceburg, Ind.

Chicago Bridge & Iron Company

500,000-gallon Elevated Tank Boosts Water Main Pressures For City of Henderson, Texas

The City of Henderson, Texas, gave a sizable boost to water pressures in its distribution system with the the recent addition of a 500,000-gallon elevated storage tank, 84¼ feet to bottom, fabricated and erected by Chicago Bridge & Iron Company.

The ellipsoidal-bottom structure increased the maximum pressure on Henderson's distribution system from 65 to 90 pounds.

Henderson's water distribution system serves about 12,000 residents and several industrial firms. The city's average daily consumption of water is about 1,100,000 gallons.

Write to our nearest office for information on CB&I elevated tanks.

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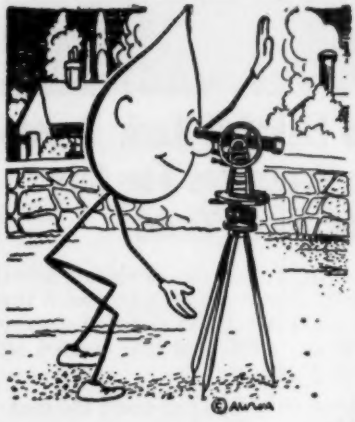

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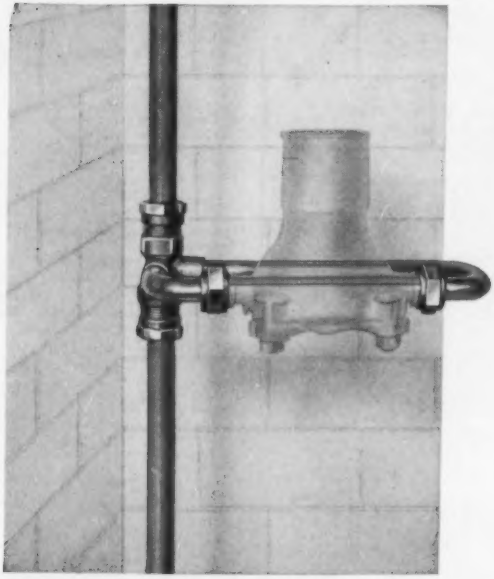

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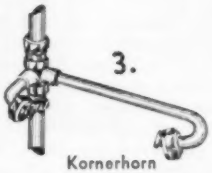

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Aqua Survey & Instrument Co.
Jos. G. Pollard Co., Inc.

Lime Slakers and Feeders:
B-I-F Industries, Inc.—Omega
Dorr-Oliver Inc.
General Filter Co.
Infilco Inc.
Permutit Co.
Wallace & Tiernan Inc.

Locators, Pipe & Valve Box:
Aqua Survey & Instrument Co.
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Magnetic Dipping Needles:
Aqua Survey & Instrument Co.
W. S. Darley & Co.

Meter Boxes:
Ford Meter Box Co.
Pittsburgh Equitable Meter Div.

Meter Couplings and Yokes:
Badger Meter Mfg. Co.
Dresser Mfg. Div.

St. Paul installing 7½ mile steel main

The pipe is being supplied by Bethlehem Steel in 40-ft lengths. Contractor is Ashbach Construction Co. Consulting engineers: Black & Veatch. St. Paul, Minnesota Board of Water Commissioners: Milton Rosen, President; Leonard N. Thompson, General Manager.

They do things in a big way in St. Paul, Minn. Back in 1920 they embarked on a 5-year, $5½-million waterworks improvement program. In 1958 they began another major project, totalling $2½ million. Both called for steel pipe, 5 ft ID.

The old riveted main, approximately 8000 ft long, is still on the job, giving excellent service after 35 years of constant use. The new main, about 41,000 ft long, is of modern welded construction. Even the girth joints are welded, making each portion of the line, in effect, a continuous length of pipe—completely leak-free.

The project, begun in 1958, is scheduled for completion in Fall of 1959, allowing for a shut-down during the winter months.

For more information about tar-enameled steel pipe, we suggest you contact the nearest Bethlehem sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

Export Distributor: Bethlehem Steel Export Corporation

BETHLEHEM STEEL

BETHLEHEM STEEL

Ford Meter Box Co.
Gamon Meter Div., Worthington Corp.
Hays Mfg. Co.
Hersey Mfg. Co.
Mueller Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meter Reading and Record Books:
Badger Meter Mfg. Co.

Meter Testers:
Badger Meter Mfg. Co.
Ford Meter Box Co.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Domestic:
Badger Meter Mfg. Co.
Buffalo Meter Co.
Calmet Meter Div., Worthington Corp.
Gamon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.

Meters, Filtration Plant, Pumping Station, Transmission Line:
B-I-F Industries, Inc.—Builders
Foster Eng. Co.
Simplex Valve & Meter Co.
Sparling Meter Co.

Meters, Industrial, Commercial:
Badger Meter Mfg. Co.
B-I-F Industries, Inc.—Builders
Buffalo Meter Co.
Burgess-Manning Co., Penn Instruments Div.
Calmet Meter Div., Worthington Corp.
Gamon Meter Div., Worthington Corp.
Hersey Mfg. Co.
Neptune Meter Co.
Pittsburgh Equitable Meter Div.
Simplex Valve & Meter Co.
Sparling Meter Co.

Mixing Equipment:
Chain Belt Co.
General Filter Co.
F. B. Leopold Co.

Paints:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.

Pipe, Asbestos-Cement:
Johns-Manville Corp.
Keasbey & Mattison Co.

Pipe, Brass:
American Brass Co.

Pipe, Cast Iron (and Fittings):
Alabama Pipe Co.
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Trinity Valley Iron & Steel Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Cement Lined:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
James B. Clow & Sons
Southern Pipe & Casing Co.
United States Pipe & Foundry Co.
R. D. Wood Co.

Pipe, Concrete:
American Concrete Pressure Pipe Assn.
American Pipe & Construction Co.
Lock Joint Pipe Co.
Vulcan Materials Co.

Pipe, Copper:
American Brass Co.

Pipe, Plastic:
Morgan Steel Products, Inc.
Orangeburg Mfg. Co.

Pipe, Steel:
Armco Drainage & Metal Products, Inc.
Bethlehem Steel Co.
Morgan Steel Products, Inc.
Southern Pipe & Casing Co.

Pipe Cleaning Services:
National Water Main Cleaning Co.

Pipe Coatings and Linings:
American Cast Iron Pipe Co.
Cast Iron Pipe Research Assn.
Centriline Corp.
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.
Reilly Tar & Chemical Corp.
Southern Pipe & Casing Co.

Pipe Cutters:
James B. Clow & Sons
Ellis & Ford Mfg. Co.
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.
E. H. Wachs Co.

Pipe Jointing Materials; see Jointing Materials

Pipe Locators; see Locators, Pipe

Plugs, Removable:
James B. Clow & Sons
Jos. G. Pollard Co., Inc.
A. P. Smith Mfg. Co.

Potassium Permanganate:
Carus Chemical Co.

Pressure Regulators:
Allis-Chalmers Mfg. Co.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Ross Valve Mfg. Co.

Pumps, Boiler Feed:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Pumps, Centrifugal:
Allis-Chalmers Mfg. Co.
American Well Works
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Chemical Feed:
B-I-F Industries, Inc.—Proportioneers
Precision Chemical Pump Corp.
Wallace & Tiernan Inc.

Pumps, Deep Well:
American Well Works
Layne & Bowler, Inc.
Peerless Pump Div.

Pumps, Diaphragm:
Dorr-Oliver Inc.
W. S. Rockwell Co.
Wallace & Tiernan Inc.

Pumps, Hydrant:
W. S. Darley & Co.
Jos. G. Pollard Co., Inc.

Pumps, Hydraulic Booster:
Peerless Pump Div.
Ross Valve Mfg. Co.

Pumps, Sewage:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Sump:
DeLaval Steam Turbine Co.
Peerless Pump Div.
C. H. Wheeler Mfg. Co.

Pumps, Turbine:
DeLaval Steam Turbine Co.
Fiese & Firstenberger
Layne & Bowler, Inc.
Peerless Pump Div.

Recorders, Gas Density, CO_2, NH_3, SO_2, etc.:
Permutit Co.
Wallace & Tiernan Inc.

Recording Instruments:
B-I-F Industries, Inc.—Builders
Simplex Valve & Meter Co.
Sparling Meter Co.
Wallace & Tiernan Inc.

Reservoirs, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Sand Expansion Gages; see Gages

Sleeves: see Clamps

Sleeves and Valves, Tapping:
James B. Clow & Sons
Ludlow Valve Mfg. Co.
M & H Valve & Fittings Co.
Mueller Co.
Rensselaer Valve Co.
A. P. Smith Mfg. Co.

Sludge Blanket Equipment:
Cochrane Corp.
General Filter Co.
Graver Water Conditioning Co.
Infilco Inc.
Permutit Co.

Sodium Aluminate:
National Aluminate Corp.

Sodium Chloride:
International Salt Co., Inc.

Sodium Fluoride:
American Agricultural Chemical Co.

Sodium Hexametaphosphate:
Calgon Co.

Sodium Hypochlorite:
Jones Chemicals, Inc.
Wallace & Tiernan Inc.

Sodium Silicate:
Philadelphia Quartz Co.

Sodium Silicofluoride:
American Agricultural Chemical Co.
Tennessee Corp.

Softeners:
Cochrane Corp.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hungerford & Terry, Inc.
Permutit Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.

Softening Chemicals and Compounds:
Calgon Co.
General Filter Co.
Industrial Chemicals, Inc.
International Salt Co., Inc.
National Aluminate Corp.
Permutit Co.
Tennessee Corp.

Standpipes, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.

Where water is used, process equipment and storage tanks are sure to corrode unless protected by an E.R.P. cathodic protection system. Even with these concrete high rate clarifiers at the St. Regis Paper Company plant near Jacksonville, Florida, it pays to protect the metal parts with an E.R.P. cathodic system.

Engineering PLUS... E.R.P. cathodic protection pays off in maintenance savings

In industry or public service, water treatment is a big investment. To protect that investment in water treatment equipment could be a tremendous maintenance job. Even with concrete clarifiers, it pays to use E.R.P. cathodic protection. When there are metal tanks involved, just one cleaning and painting can cost more than a complete E.R.P. cathodic protection system.

From preliminary design to continuing periodic corrosion surveys, experienced corrosion engineers measure, analyze and design specifically for your corrosion problems. That is the only way corrosion can be virtually eliminated.

E.R.P. engineering plus prevents corrosion of water storage tanks, water and sewage treatment structures and pipelines. For full information on how E.R.P. can help you save maintenance costs, write for bulletin E-46.05.

ERP CATHODIC PROTECTION SINCE 1935

ELECTRO RUST-PROOFING CORP.

A SUBSIDIARY OF WALLACE & TIERNAN INC.

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CABLE: ELECTRO, NEWARK, N. J.

Hammond Iron Works
Pittsburgh-Des Moines Steel Co.

Steel Plate Construction:
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Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Morgan Steel Products, Inc.
Pittsburgh-Des Moines Steel Co.

Stops, Curb and Corporation:
Ford Meter Box Co.
Hays Mfg. Co.
Mueller Co.

Storage Tanks: see Tanks

Strainers, Suction:
James B. Clow & Sons
R. D. Wood Co.

Surface Wash Equipment:
Golden-Anderson Valve Specialty Co.
Permutit Co.

Swimming Pool Sterilization:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Omega
B-I-F Industries, Inc.—Proportioneers
Wallace & Tiernan Inc.

Tanks, Prestressed Concrete:
Preload Co., Inc.

Tanks, Steel:
Bethlehem Steel Co.
Chicago Bridge & Iron Co.
Graver Tank & Mfg. Co.
Hammond Iron Works
Morgan Steel Products, Inc.
Pittsburgh-Des Moines Steel Co.

Tapping-Drilling Machines:
Hays Mfg. Co.
Mueller Co.
A. P. Smith Mfg. Co.

Tapping Machines, Corp.:
Hays Mfg. Co.
Mueller Co.

Taste and Odor Removal:
B-I-F Industries, Inc.—Builders
B-I-F Industries, Inc.—Proportioneers
General Filter Co.
Graver Water Conditioning Co.
Industrial Chemical Sales Div.
Permutit Co.
Wallace & Tiernan Inc.

Turbidimetric Apparatus (For Turbidity and Sulfate Determinations):
Wallace & Tiernan Inc.

Turbines, Steam:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Turbines, Water:
Allis-Chalmers Mfg. Co.
DeLaval Steam Turbine Co.

Valve Boxes:
James B. Clow & Sons
Ford Meter Box Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
A. P. Smith Mfg. Co.
Trinity Valley Iron & Steel Co.
R. D. Wood Co.

Valve-Inserting Machines:
Mueller Co.
A. P. Smith Mfg. Co.

Valves, Altitude:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Golden-Anderson Valve Specialty Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Butterfly, Check, Flap, Foot, Hose, Mud and Plug:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
Chapman Valve Mfg. Co.
James B. Clow & Sons
DeZurik Corp.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
R. D. Wood Co.

Valves, Detector Check:
Hersey Mfg. Co.

Valves, Electrically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.

Valves, Float:
James B. Clow & Sons
Golden-Anderson Valve Specialty Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co., Inc.

Valves, Gate:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Dresser Mfg. Div.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Hydraulically Operated:
Allis-Chalmers Mfg. Co., Hydraulic Div.
B-I-F Industries, Inc.—Builders
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
DeZurik Corp.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
F. B. Leopold Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Large Diameter:
Allis-Chalmers Mfg. Co., Hydraulic Div.
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Kennedy Valve Mfg. Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Valves, Regulating:
Allis-Chalmers Mfg. Co., Hydraulic Div.
DeZurik Corp.
Foster Eng. Co.
Golden-Anderson Valve Specialty Co.
Mueller Co.
Henry Pratt Co.
W. S. Rockwell Co.
Ross Valve Mfg. Co.

Valves, Swing Check:
Chapman Valve Mfg. Co.
James B. Clow & Sons
Darling Valve & Mfg. Co.
Golden-Anderson Valve Specialty Co.
Ludlow Valve Mfg. Co., Inc.
M & H Valve & Fittings Co.
Mueller Co.
W. S. Rockwell Co.
A. P. Smith Mfg. Co.
R. D. Wood Co.

Venturi Tubes:
B-I-F Industries, Inc.—Builders
Simplex Valve & Meter Co.

Waterproofing:
Inertol Co., Inc.
Koppers Co., Inc.
Plastics & Coal Chemicals Div., Allied Chemical Corp.

Water Softening Plants; see Softeners

Water Supply Contractors:
Layne & Bowler, Inc.

Water Testing Apparatus:
LaMotte Chem. Products Co.
W. A. Taylor & Co.
Wallace & Tiernan Inc.

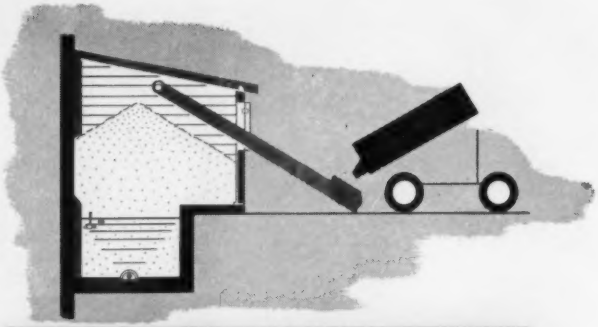
Water Treatment Plants:
American Well Works
Chain Belt Co.
Chicago Bridge & Iron Co.
Dorr-Oliver Inc.
General Filter Co.
Graver Water Conditioning Co.
Hammond Iron Works
Hungerford & Terry, Inc.
Infilco Inc.
Permutit Co.
Pittsburgh-Des Moines Steel Co.
Roberts Filter Mfg. Co.
Walker Process Equipment, Inc.
Wallace & Tiernan Inc.

Well Drilling Contractors:
Layne & Bowler, Inc.

Wrenches, Ratchet:
Dresser Mfg. Div.

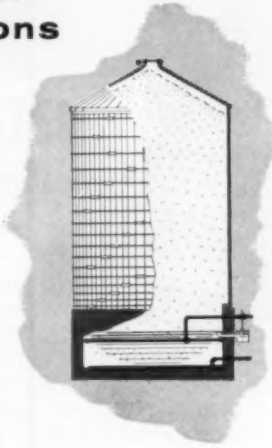
Zeolite: see Ion Exchange Materials

A complete Buyers' Guide to all water works products and services offered by AWWA Associate Members appears in the 1957 AWWA Directory.



BRINE LEVEL

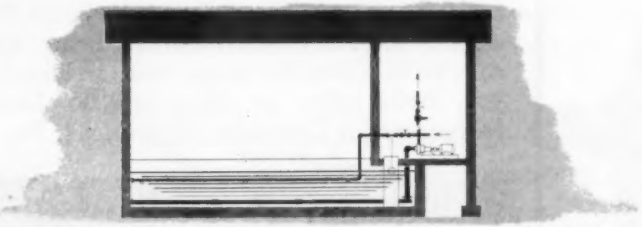
How it can affect design of water softening installations



What's the best brine level for a 500-gallon-per-hour salt dissolver? Your answer is bound to influence the type of dissolver construction needed, as well as the cost of operating the equipment. The lower the level, the less expense there will be in waterproofing the bottom portion of the dissolver. But too low a level can seriously reduce brine-making efficiency, and thus boost brine-making costs.

It is essential, therefore, to reach the best compromise between original construction cost and subsequent operating expense by specifying the correct brine level. Here's where International Salt Company is ready to help. 50 years of experience and continuing research in all phases of salt handling and brine production make International the leading authority on matters concerning salt purchase, storage and dissolving for regenerating ion exchangers. This knowledge is especially valuable in view of the ever-growing amounts of brine being used today.

Service and research are the extras in STERLING SALT



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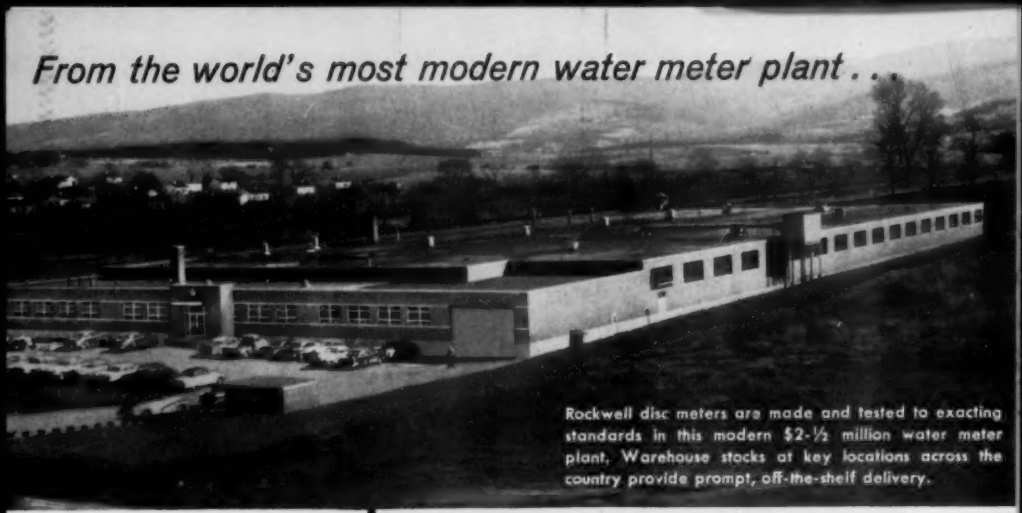
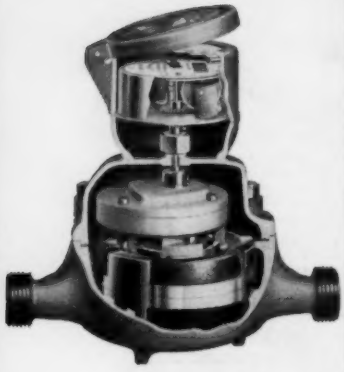
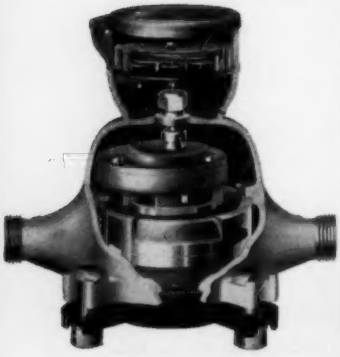
From the world's most modern water meter plant . . .



Rockwell disc meters are made and tested to exacting standards in this modern $2-½ million water meter plant. Warehouse stocks at key locations across the country provide prompt, off-the-shelf delivery.



Tropic Type



Arctic Type

THE BEST DISC METERS YOU CAN BUY

For all these good reasons

Rockwell disc meters are made with costly *stainless steel trim* to assure corrosion resistance and durability. Their construction includes a patented *"O"-ring stuffing box assembly* which stops leaks, binds, troubles and expense. Another extra value is the *large red center test hand* on all registers which provides a closer check on accuracy and a convenient means for determining leaks on customer's premises. And even parts for Rockwell disc meters are neatly packaged in convenient quantities to stack on shelves—eliminate the need for bulky bins—simplify inventory control and reordering. All this adds up to better disc meter values and service for you. Write today for latest bulletins. Rockwell Manufacturing Company, Pittsburgh 8, Pa.

DISC TYPE WATER METERS

another fine product by

ROCKWELL

DORRCO PERIFILTER SYSTEM...

at Summit, New Jersey Water Treatment Plant... to provide 15 MGD for suburban communities

The modern Canoe Brook Station of the Commonwealth Water Company is currently fulfilling the water requirements of several New Jersey suburban communities. A Dorrco PeriFilter System was selected for this plant as the most economical solution for local conditions. Heart of the system are four Dorrco Hydro-Treators, each 63'6" in diameter with a 16'3" sidewater depth, and each surrounded by an annular sand filter. Flow through each unit is normally 2.5 MGD, with a maximum unit flow of 3.75 MGD enabling a total plant flow of 15 MGD. The Canoe Brook plant was designed to remove turbidity, color, iron and manganese.

The Summit, New Jersey installation is another endorsement of the widely proven advantages of the Dorrco PeriFilter System and Dorrco Hydro-Treators for removal of turbidity, color, hardness, or algae from municipal water supplies. For more information write for Bulletins 9041 and 9042.

Consulting Engineers: American Water Works Service Company, Inc.
Philadelphia, Pennsylvania

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WORLD-WIDE RESEARCH • ENGINEERING • EQUIPMENT
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LEADITE

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Jointed for . . . Permanence with LEADITE

Generally speaking, most Water Mains are buried beneath the Earth's surface, to be forgotten,—they are to a large extent, laid for permanency. Not only must the pipe itself be dependable and long lived,—but the joints also must be tight, flexible, and long lived,—else leaky joints are apt to cause the great expense of digging up well-paved streets, beautiful parks and estates, etc.

Thus the "jointing material" used for bell and spigot Water Mains MUST BE GOOD,—MUST BE DEPENDABLE,—and that is just why so many Engineers, Water Works Men and Contractors aim to PLAY ABSOLUTELY SAFE, by specifying and using LEADITE.

Time has proven that LEADITE not only makes a tight durable joint,—but that it improves with age.

The pioneer self-caulking material for c. i. pipe.
Tested and used for over 40 years.
Saves at least 75%

THE LEADITE COMPANY
Girard Trust Co. Bldg. Philadelphia, Pa.

No Caulking